ATOMIC ENERGY COMMISSION APPROPRIATIONS FOR 1960

HEARINGS

BEFORE THE

SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS HOUSE OF REPRESENTATIVES

EIGHTY-SIXTH CONGRESS

FIRST SESSION

SUBCOMMITTEE ON PUBLIC WORKS APPROPRIATIONS

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Printed for the use of the Committee on Appropriations

UNITED STATES
GOVERNMENT PRINTING OFFICE
43118 WASHINGTON : 1959

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ATOMIC ENERGY COMMISSION APPROPRIATIONS FOR 1960

MONDAY, JUNE 15, 1959.

WITNESSES

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DR. P. C. AEBERSOLD, DIRECTOR, OFFICE OF ISOTOPES DEVELOPMENT
F. J. McCARTHY, JR., ASSISTANT CONTROLLER FOR BUDGETS

Mr. CANNON. The committee will be in order. We take up this morning the budget for the Atomic Energy Commission, one of the most important subjects to come before the Congress this session.

We have with us General Luedecke, General Manager of the Atomic Energy Commission. Chairman McCone will be along presently. I understood he got in from abroad this morning at 1 o'clock.

This morning will be devoted largely to orientation. We shall not discuss the budget proper. We should like to become acquainted with the subject generally and the developments made since our last session.

Before I ask for a general statement, I might ask what can you tell us about the importance of the development of atomic energy?

Dr. LIBBY. I think, Mr. Cannon, it continues to be of overwhelming importance in the area for our defense and is of growing importance in the civilian area, but in the military area it is absolutely overwhelming.

RELATIONSHIP BETWEEN ATOMIC ENERGY AND ELECTRICITY

Mr. CANNON. Of course, this committee desires to discuss both phases. So universal has become the use of electricity that it is of prime importance in the economy and industry of the Nation and in the routine of every family in the United States. Electricity is becoming, with all of our modern appliances, almost as essential as air, water, and light. Last winter in the city of St. Louis there was threat of a strike which might interrupt the supply of power, and I received frantic letters saying that if electric power was discontinued families in St. Louis would freeze, and practically all industry would be paralyzed, emphasizing the vital importance which this subject plays in the peacetime history of the Nation and, of course, in time of war it is even more vital as practically all modern war machinery is geared to electricity.

I would also like to ask, What is the relation between atomic enrgy and electricity in our foreseeable future?

Dr. LIBBY. This is the $64 question, Mr. Chairman, as to whether we can make it economic or not. We think so, and we aim to try to do so within the next 10 years in this country. But I think it still must be demonstrated conclusively that it is competitive with fossil fuel and waterpower. It is one of those things to be settled. I think it is. There is no doubt of that in certain areas of the world. Taking the Navy, atomic power is the answer in many applications. We all believe in it, but I think it is fair to say that there are some people who have doubts that it is competitive. In the long run when the world runs out of, or depletes, its resources of coal and oil, then the uranium will take over. But the question in the short run is the $64 question. We are getting cheaper power from nuclear energy all the time. Things look better and better.

Mr. CANNON. The application of atomic energy to industry.

Dr. LIBBY. That is right. It becomes more and more practical.

APPLICATION OF ATOMIC ENERGY TO INDUSTRY

Mr. CANNON. In that respect we had the lead in the beginning, but apparently today we have dropped back, or at least behind England, if not Russia. Both Italy and Japan are buying British reactors. So apparently while America was expected to take the lead and should have taken the lead, we having originated its study and development, we have permitted through dalliance or neglect of our opportunities other nations to take the lead in the application of atomic energy to industry.

Now atomic energy gives us a vastly wider range in seapower, airpower, and every phase of war. In the domestic field, in the average family, it is expected to decrease materially the cost of electric service?

Dr. LIBBY. I think in due course this will happen, Mr. Cannon. Right now we are having quite a struggle to make it competitive with coal and oil.

DEVELOPMENT IN ENGLAND

Mr. CANNON. It is already competitive in England, but in England their primary fuels are more expensive than ours. In England they have already made it competitive and it is adding materially to the English economy.

Dr. LIBBY. It is a little bit difficult to say exactly. I think your statement is pretty nearly right.

Mr. CANNON. They are actually integrating it at Calder Hall and it is being adapted to industry in competition with coal.

Mr. JENSEN. Mr. Chairman.

Mr. CANNON. The gentleman from Iowa.

Mr. JENSEN. As you know, Mr. Rabaut and I visited England in the fall of 1957 to look into the atomic energy reactor program of England. We visited Calder Hall and we also visited the plant at Dounreay, the breeder reactor plant which was not completed at that time. I don't know that it is completed yet.

Dr. LIBBY. It is getting close.

Mr. JENSEN. Of course, we had a number of meetings with the Atomic Energy Commission of England, and with the Electric Power Administration. It is true that the atomic energy that is produced at Calder Hall is integrated into the British power grid, but all of the officials that had anything to do with the electric power and atomic power of England admitted that it was still very expensive to produce power by the atomic energy system. Of course, their coal is expensive over there, because of the simple fact that the mines have never been mechanized. The labor unions refuse to let the mines be mechanized because they fear it would cause unemployment in the mining industry.

So far as electric power being produced cheaper in England by atomic energy, it is not. The Administration for Power in England, all power being owned by the Federal Government—there are no hydro powerplants in England, of course the Atomic Energy Commission charges the Electric Power Administration 8 mills a kilowatt-hour. We asked them how much it was costing to produce the electricity by atomic power. They never did give us, as Mr. Rabaut will verify, the exact figure. Of course, they are making plutonium also, and I think it was difficult for them to say just how much it was costing them to produce atomic energy. But I gather it was costing them at least 25 mills for it, or 2½ cents. In fact, one of the members off the record told me as near as they could figure it was costing them 2½ cents a kilowatt-hour to produce electric energy which would be prohibitive in this country, since, as you know, we are producing power through hydro plants as well as steam plants for around 4 mills a kilowatt-hour. They have the gas-cooled system producing electric power by atomic energy. We have a water-cooled system here, and we are far ahead of them, in my opinion, so far as producing power at a cheaper rate is concerned. I don't think there is any question at all but that we are producing electric power for half the price that England is producing electric power today. I am sure the record will so prove.

So I am proud of the fact, because of the manner in which we are developing atomic power through the cooperation of private enterprise with the Atomic Energy Commission, that we have made great advances in the production of atomic power for electric power.

Mr. CANNON. Mr. Rabaut.

GAS-COOLED REACTOR

Mr. RABAUT. I judge the situation somewhat similarly, but I have a great respect for a fellow when he puts his money into something and does it continuously, as England is doing with the gas-cooled reactor. The gas-cooled reactor has never been praised very much to us by the Commission in their various appearances before the Committee. But we went over there and actually saw it in operation. They are tying it into the electric grid and have a program for the future to build more of these plants. They told us that was comparable in cost now to what a standard operation cost with their cost of coal. Their coal is around $20 a ton, I think. They are tying that into their system. Of course, they have not the greatly enriched uranium that we have developed here, which has a tremendous cost to it, because of the plant that does the enriching, as I understand it.

Dr. LIBBY. Yes.

Mr. RABAUT. They are creating some plutonium, but it is nothing compared to what we are doing here. Thinking about that enriched uranium and its cost, I have the feeling there is something to the argument that we are not reducing the cost of atomic energy with that type of enrichment. Where you use more fuel and get a lower degree of heat, you have not got the maximum efficiency that you get with the enriched fuel. But you also have not got the cost.

For some countries that will be wanting these plants, I doubt very much if they are going to be dependent upon a country that is so far away as we are from them, in days of trouble in the world, for their supply of the enriched fuel. They will more or less seek the standard type of fuel under the atomic program. Maybe I am wrong in that, but that was my deduction when I was over there. I think for that reason you are going to find that we are not going to get the sales to these countries of our type of development, calling for enriched fuel. That has been the experience we have had so far with these other people buying these outfits to produce atomic energy. Do you agree with me?

Mr. JENSEN. Yes, to a very great degree. I think we saw this thing in just about the same light. The Atomic Energy Commission here has not put as much effort on the gas-cooled reactor as England has.

Dr. LIBBY. We are beginning.

EXCHANGE OF KNOWLEDGE

Mr. JENSEN. It was because we thought in this country we could take advantage of England's knowledge of the gas-cooled reactor. They have put very little emphasis on the water-cooled reactor which we have brought forward for the same reason; that is, the Atomic Energy Commission felt that since we had a complete cooperative understanding it would be a duplication of effort. It is true they went forward faster on the gas-cooled reactor than we did and have the machinery now ready to sell to other countries. We do know also they went so fast in the development of the gas-cooled reactor that they did not make the reactor foolproof, and they had an incident.

Mr. RABAUT. An incident.

Mr. JENSEN. Yes; you would not call it an accident that has cooled off the other countries to this reactor to a great degree.

Mr. RABAUT. When we went over there, Mr. Chairman, I went to you and said that the reason we ought to go now is because this reactor at Dounreay was about to go critical. They said they were going to put it on in February. We went over there in the fall.

Mr. JENSEN. They said it was 85 percent complete then.

Mr. RABAUT. They said it was practicually finished and they were walking around with these cloth socks over the shoes so as not to distribute any dust, and all that. I understand that it has not started yet.

Dr. LIBBY. I am just asking Dr. Pittman for the last word.

Mr. RABAUT. Really they did not do so well with that reactor. That is called the breeder type, and that is one of the most critical of all types of reactors.

Dr. LIBBY. He is going to check the last information.

Mr. CANNON. We will reach that in due time. We will take up each of these questions as we come to them.

Mr. PILLION. Off the record.

(Discussion off the record.)

PROGRESS IN ENGLAND

Mr. CANNON. The one essential thing to remember and the one decisive factor is that England, producing atomic energy and feeding it into English economy, is increasing every month the amount of energy produced and the amount of energy delivered to industry. That is in itself conclusive. They would not be continuously increasing the amount they are producing and the amount that they are delivering if it were not financially advantageous. They are using the gas-cooled method. Our Commission arbitrarily refused to use the gas-cooled method. We had to direct them to do it before they would yield.

The gentleman from Iowa.

Mr. JENSEN. Mr. Chairman, I don't know that all of this stuff should be discussed for the record.

Mr. CANNON. Yes. The American people should know the facts and we don't want to conceal anything. We want to throw it wide open so that everybody can see it.

The gentleman from Iowa.

Mr. JENSEN. I just gave some facts a minute so. The facts are, of course——

Mr. CANNON. The gentleman has already given them. They are on the record.

POLICY RELATIVE TO POWER IN ENGLAND

Mr. JENSEN. The policy of England is that all the electric power should be nationalized, so all private industry and all the money that private industry had before that time invested in the electric power production of England was thrown out the window. So what

happened? The electric power production of England was not keeping up with the demand. It was falling far behind the demand. Then the Atomic Energy Commission came in and built atomic energy plants for power. It was a costly thing. Everybody in England who has anything to do with the atomic energy will tell you that it was a mighty costly way to produce electric power. They do throw their power into the English grid system. They have to. There is no other way to dispose of it because private industry has no part, and can have no part in producing power or transmitting power in England.

So far as the gas-cooled system of producing power is concerned, I am sure it has no advantages over our system which has been developed here by the Atomic Energy Commission of producing power with the water-cooled system. In fact, the record will show that we are producing power with a water-cooled system much cheaper than England is producing it with a gas-cooled system.

As I said before, Mr. Chairman, so long as England and the United States have a working agreement where we take advantage of their know-how in producing power and electric energy by the atomic energy system, and they have the privilege of using our methods of producing electric power by every kind of atomic system that we have, which is several in number, as you know, then certainly the Atomic Energy Commission of the United States cannot be criticized nor condemned for what they have been doing. Certainly they have been doing a good job, and with the cooperation of private industry which has spent more money many times over than the Federal Government in the development of power from atomic energy and has proven that it can produce power much cheaper with the systems which we are using than England is using today. I feel very well satisfied with the job that the Atomic Energy Commission has been doing under sometimes most difficult obstacles from Members of Congress who are constantly critizicing the atomic energy program. I cannot understand how it can be justified, looking at the record.

Mr. CANNON. The fact remains that we originated and first applied atomic energy to industry. We built the first reactors, thanks to Admiral Rickover. With that lead, we expected to market our reactors to other countries. When the time came and they were on the market, foreign nations bought from England and not from us. That is decisive. Also, England is constantly increasing her production and her distribution of atomic energy in its practical applications to industry.

DISCUSSION OF PUBLIC VERSUS PRIVATE POWER

Now the gentleman from Iowa has emphasized the question of public power and private power. Apparently that was the consuming objective motivating the Atomic Energy Commission. It was an obsession and they were determined to permit private industry to monopolize the production and distribution of atomic energy.

That is why they so determinedly opposed REA. That is why they so opposed TVA. That is why they are opposing municipal ownership.

If they can once get a monopoly in this method of controlling the largest item in cost of production in industry and in cost of living in the American family, the consumer will be at their mercy.

REA does not merely concern the farm family. It is holding down both urban and rural rates by showing how cheaply and effectively electricity can be produced and distributed.

No advocate of public power favors public monopoly. We merely wish to protect the public against private monopoly.

The consumers of America should be able to buy at a reasonable rate this most important item in cost of production and cost of living. The Power Trust should not be in a position to dictate rates or conditions of service as reflected in weekly or monthly bills, and charge the consumer more than a fair return upon their investment.

Mr. TABER. Mr. Chairman.

Mr. CANNON. The gentleman from New York.

Mr. TABER. Should we not get the evidence from the Commission so that we might find out what the facts are?

Mr. CANNON. Yes, but we want to establish in the beginning just what our objective is. The purpose of this meeting is orientation. We want to outline the problems and conditions so plainly that the American people who have so much at stake, will know when they read these hearings what predatory power is trying to do and what we are trying to do to protect the consumer. We came near losing REA once before the public realized what was happening.

Mr. EVINS. Will the chairman yield?

Mr. CANNON. I yield to the gentleman from Tennessee.

Mr. EVINS. I am perfectly agreeable with Mr. Taber to listen to the experts. These men are capable. They are the men we are going to have to depend upon. But I am not in agreement with our friend from Iowa, Mr. Jensen, when he says he is satisfied. He is perfectly willing to close the books right now.

Mr. JENSEN. Now, wait.

Mr. EVINS. You talked two or three times. Let me say something!

Mr. JENSEN. I did not accuse you or anybody else of wanting to close the books.

Mr. EVINS. I did not mean to leave any wrong impressions. The gentleman said "As far as I am concerned, I am satisfied." I am not satisfied with the progress we are making in this country. I think the Atomic Energy Commission has some of the most able men in this Nation. They are expert, outstanding, and capable. It is a matter of direction.

Mr. JENSEN. I don't propose to sit here and have them abused, ridiculed, and insulted every day.

Mr. EVINS. They are able men. Congress should set the policy in this country. It is a matter of direction and policy. I have a feeling they have a nice comfortable building in Germantown; they spend several hours going back and forth; they are in air-conditioned quarters, well set up and able men; but there is no direction. We can hear the testimony and we can determine the facts from that. We ought to hear from the experts. These are the men. I am not satisfied with the progress we are making.

Mr. CANNON. The gentleman from Pennsylvania.

RELATIVE PROGRESS BETWEEN ENGLAND, RUSSIA, AND THE UNITED STATES

Dr. FENTON. May I ask the witnesses, who should be the experts in this case, whether or not they agree with the statement made by the Chairman, that apparently England, and possibly Russia, have gone ahead of the United States in nuclear development.

Dr. LIBBY. I would prefer to have you ask the Chairman of the Commission, Mr. McCone, who is not here today. He got back early this morning from Geneva.

Mr. CANNON. When he comes in, we shall be glad to have him answer that question. Of course, it is not a matter of opinion. It is a matter of who is selling the reactors to the other nations of the world. That is the criterion.

The gentleman from New York.

Mr. PILLION. I would like to state for the record that I do not concede that the Russian Government or the Soviets are ahead of us in the missile field or the atomic energy field or in total military power.

Mr. CANNON. That is a fine American statement. We were inclined to congratulate ourselves that was the situation until the Soviet Government, coming from behind, put up the sputnik when we could not get through the stratosphere. It was pretty hard for us to explain that. We are accustomed to make statements every day in the year that we are the greatest nation on earth. We would like to believe that.

Mr. Luedecke, do you have a prepared statement?

Dr. LIBBY. Mr. Chairman, the general has asked me to give it, since it is his first appearance.

Mr. CANNON. Certainly.

ORIENTATION PRESENTATION

Dr. LIBBY. I am Willard Libby, member of the Commission. We would like to express our pleasure, Mr. Cannon, at the opportunity to present to you this orientation on atomic energy before taking up our appropriation request for fiscal 1960.

Mr. CANNON. We shall be glad to hear it at this time.

Dr. LIBBY. Mr. McCone will be available, but he got in early this morning; however, he will be glad to come down this morning if you wish. He definitely will be here tomorrow.

Mr. CANNON. That will be entirely satisfactory to the committee.

Dr. LIBBY. I am sure you are acquainted with the other Commissioners and the members of the staff who are present, with the possible exception of our new General Manager, General Luedecke. He assumed his duties last December. Dr. Pittman, whom we heard a moment ago, has, since his last appearance before you, been appointed Director of the Division of Reactor Development—the job that Mr. Kenneth Davis had during the hearings last year.

As I say, we are very happy the committee has decided to give us their time for the orientation and should serve to refresh our memory as to the mention of terms and basic processes involved, to indicate the status of our knowledge, and the progress toward understanding the nature of the atom and the forces controlling it, and to anticipate some of the potential problems in harnessing these forces for the betterment of mankind.

This presentation has been prepared in close coordination with the committee staff in an effort to provide the best assurance of the coverage desired. Our problem has been that of compressing as much information as we could into the time available. We are sure it will not cover all the points you may have had in mind, but we will do our best to answer those which may arise.

You have been provided an outline of the presentation, listing the subject to be covered, the name of the person, and an indication of the time. It is a full schedule, but we feel it is important to clarify any points as we go along; so questions are welcome.

OUTLINE OF PRESENTATION

In making this presentation, Mr. Chairman, we propose to begin with a short movie entitled, "The Basic Physics of the Atomic Bomb," which, I think, provides a basic understanding of atomic energy. The running time is 19 minutes. We can use this film as something of a springboard for the remainder of the discussion.

Following that, Dr. Williams, our Director of the Division of Research, will take some time to discuss the basic principles of physics which underlie atomic energy.

The first practical application of atomic energy was, as you know, to weapons. It seems appropriate, therefore, that following Dr. Williams' discussion of the basic principles, we turn directly to the subject of atomic weapons; and General Starbird, Director of the Military Applications Division, will present some of the basic facts about nuclear weapons and how they are made.

Before winding up the morning, the tentative schedule we have discussed calls for a brief discussion of how we obtain the raw materials from which the special nuclear materials are processed. Mr. Jesse Johnson, Director of Raw Materials, will describe what is involved in obtaining uranium ore and concentrates.

Mr. Bloch, our Director of Production, will then describe how we manufacture from these concentrates the fissionable materials, uranium 235 and plutonium, which make the weapons. While these production operations today proceed—and I want to emphasize strongly this part of my statement—while these production operations today proceed with a minimum of fuss and bother, this very fact is, I think, the measure of the strength and success of our efforts during the last 12 years of operation.

After lunch, we propose to have Dr. Pittman discuss the field of reactors and maybe you will get some answers to some of the questions you have been raising. It is hardly necessary to say that some of our most challenging problems today, and for some years to come, lie in the field of reactor development. Dr. Pittman will indicate to you the basic principles governing reactors—that is to say, how a reactor works. These same principles and the associated problems apply to all reactors whether intended for propulsion of airplanes or naval vessels, to make radioisotopes, or to make electric power.

Following this we have asked Dr. Williams to return for a brief explanation of the principal machines used in high-energy physics to explore the secrets of the atom and to find new ways to put nuclear energy to work for man's benefit. Dr. Williams will tell us something about the nature of these very large accelerators—such as the Brook-

haven cosmotron, the Berkeley bevatron, and the still larger machines now under construction and being planned.

I believe Dr. Williams will also mention some of the thermonuclear devices we are working on by which we hope to produce full energy from the fusion of atoms in the same manner energy is now produced in the sun and stars.

The next presentation will be made by Dr. Dunham, our Director of Biology and Medicine. A discussion of atomic energy would not be complete if we were not to turn our attention to the problems of identifying and controlling the hazards associated with radiation and the constructive efforts to bring benefit to man through the application of radioisotopes through medical and biological research.

The final presentation on our tentative schedule will be made by Dr. Paul Aebersold, the Director of Isotope Development.

Mr. CANNON. As I understand, we are following the schedule you have given us.

Dr. LIBBY. Yes.

Mr. CANNON. When will you show the film mentioned here?

Dr. LIBBY. In just a minute.

Mr. CANNON. You may proceed.

Dr. LIBBY. At the present time we are recovering and using only a small fraction of the isotopes formed in the reactor operation. In the brief period of years made available, hundreds of uses of these isotopes have already been found and very large benefits are being realized at very nominal cost.

Mr. RABAUT. They are tracers.

Dr. LIBBY. That is right. The beta thickness gage where you measure the thickness of a piece of steel as it comes off the rolling mill by having a radioactivity above it and a geiger counter below it. The counter tells you how thick the steel is. You don't have to touch it. It reads it accurately and cheaply. You can feed this information back to the setting of the mill, and it is of quite large benefit, that one little simple thing, and there are many others. We believe the potentiality for isotopes is a story that needs to be better known. We talk a lot about atomic power, but we don't talk enough about isotopes in my opinion.

Mr. Chairman, we are now ready to begin with the movie.

Mr. CANNON. Will you tell us, Mr. Libby, who prepared this program, and the purpose of the film?

Dr. LIBBY. I will have to ask the General Manager.

PURPOSE OF THE FILM "THE BASIC PHYSICS OF THE ATOMIC BOMB"

General LUEDECKE. The film was prepared in this case by the Armed Forces special weapons project of the Department of Defense, its purpose being to give the trainees an understanding of the physics of a nuclear weapon. While it is addressed to a nuclear weapon, the the film itself is about basic physics and it is applicable to any of the areas of atomic energy, including reactors.

Mr. CANNON. And it is a part of the regular course given the Army men who participate in this program?

General LUEDECKE. Yes, sir. It is one of a number of training films that are used by the Armed Forces special weapons project in orientation and particularly in training of those personnel who are

going to be expected to handle weapons, in research, development, production, storage, surveillance, and so on.

Mr. CANNON. Just in advance, if you will permit, may we have some idea of what is coming, what do you propose to show in this film?

Dr. LIBBY. The film will explain the meaning of the splitting of the atom, the resultant products, explain what isotopes are, what neutrons, protons, electrons are, and their relationship to the energy that is given off by application of the atom, in this particular case in a weapon, although it also explains how it needs to be handled in a controlled manner to provide energy such as in a reactor or other power applications.

Mr. CANNON. You may proceed.

(Showing of film.)

Mr. CANNON. Has this film been made available to the physics classes of the high schools?

General LUEDECKE. I don't believe I can answer that specifically.

Mr. CANNON. Is there anything in it of a classified nature that would prevent its being used in the high schools? It seems to me an informative film of that character ought to be made available to high school students. May I ask if you can include in the record here the sound track of the film just shown us?

(The material requested follows:)

SOUND TRACK TO FILM "BASIC PHYSICS OF AN ATOMIC BOMB"

Teeing off on the subject of the atomic bomb requires that you focus your attention properly. Keep your eyes where they belong, on the ball—because it serves to lead us into a minute universe, containing things so infinitesimal they are hard to imagine unless we change our concepts of size and space, and the change comes easier by taking a quick glimpse of golf, a game involving the manipulation of a small sphere, the ball, on the surface of another sphere about 300 million times as large, the earth. For a golf ball is about 300 million times as large as each of the atoms which make up its elements. If an atom is so small, how can we know anything about it? By observing its effects. You can't see the wind either, but you can see what it does and you know from recent history what the atom can do—it's a mighty might yet it becomes immense when we look inside it and compare the whole to its parts. This, an atom of hydrogen, which is one of the principle elements found in a golf ball, is the simplest of all atoms. It consists of a negatively charged light particle called an electron which revolves in an orbit about a nucleus. The nucleus of a hydrogen atom is made up of a single particle with a positive electrical charge and is known as a proton. To reemphasize the submicroscopic nature of our subject, if we could increase the size of a nucleus proton to that of a golf ball, the route of the electron would be about a mile away.

Hydrogen is one of the most common elements found in nature. As a gas it has many uses, one of them is fuel for welders torches. Scientists have classified and arranged elements according to their atomic structure, and hydrogen with its single proton gets first billing. It is assigned the atomic number 1 which refers to the proton. The ability of an element's atoms to form chemical compounds, as hydrogen combined with oxygen to form water, is governed by the atom's electrons. In another form of hydrogen there is a second particle in the nucleus. It carries no electrical charge, however. In the free natural state the number of electrons and protons is the same, and the additional uncharged nuclear particle does not effect chemical behavior. We can do it as supercargo, deadweight, passenger going along just for the ride. It is called a neutron. It gives this form of hydrogen an atomic weight of 2; the sum of the protons and neutrons in the nucleus. Different forms of the same element with different weights but carrying the same electrical charges and having identical chemical behavior are known as isotopes. For example, adding this neutron to a standard atom of hydrogen would produce this isotope of hydrogen known as deuterium. This is the hydrogen in heavy water. Adding another neutron produces a third

hydrogen isotope called tritium. One rung above hydrogen on the ladder of elements is helium.

One of the uses for helium you're probably familiar with is in lighter-than-air craft. A helium atom has two electrons and a nucleus composed of two protons, plus two neutrons, so helium has the atomic number 2, same as the protons which it possesses and the atomic weight of four—it's protons plus neutrons. Going up the latter, we find elements with atoms that become progressively complicated with more electrons and increased numbers of protons and neutrons in their nuclei. For example, a neutral carbon atom with an atomic number of 6 has six electrons. In the nucleus are six protons plus six neutrons. So the atomic weight is 12.

Carbon exists in many forms. High and humble, as diamonds and pencil points. At the top of nature.s ladder is the most complex atom, uranium—with an atomic number of 92. Naturally occuring uranium has three isotopic forms with atomic weights of 234, 235, and 238. Uranium and its neighboring elements are maladjusted. Their atoms have an unstalbe number of protons and neutrons. So, observing nature's law against lack of balance and symmetry, they try to become stable by getting rid of their excess nuclear freight. The manifestation of this inner struggle is known as radioactivity. The adjustment may release energy in three ways. Beta particles bearing a negative charge are expelled from the nucleus. They are essentially high-speed electrons. Alpha particles may also be shot out. They consist of two protons plus two neutrons and are positively charged. They are the same as the nucleus of a helijm atom. Or the energy may be in the form of gamma rays. Electro-magnetic radiations like X-rays. Natural radioactivity causes these heavy, unstable elements to decay progressively down the ladder, eventually reaching a stable form of lead. The unit for measuring the rate of such changes or transputations is the half life, the time required for 50 percent of a radioactive material to decay. To illustrate, suppose you had a gallon of whisky and each day you drank half the amount of the bottle. The first day you drank half a gallon and the whisky's half life would be 1 day. The second day, assuming, for the sake of science, you'd be able to sit up and take it, you knock off 50 percent of the remainder, or 1 quart. The third day a pint, and so on, but you'd never quite get to the bottom of the bottle. There'd always be a half remaining. The fact that some radioactive matter always remains is not so important as the time required for the half to decay. Half life there is from isotope to isotope. It takes 4,500 million years for half a hunk or uranium 238 to become thorium 234. The half life of radium 226 is 1,600 years. That of radon is slightly less than 4 days, while others have half lives of fractions of a second.

So far we've been watching natural radioactivity. Man has stepped into the act, however, and, in some cases, outdone nature. Using as his gun cyclotrons and other accelerators and employing hydrogen and helium nuclei, neutrons, protons, electrons, and other minute bullets, he has made stable matter unstable, produced radioactive isotopes of many elements. He transmutes lithium into helium with a hydrogen nucleus as the projectile. By striking the nucleus of a chromium atom with a helium nucleus he changes it into radioactive manganese with the omission of a proton. Manganese in turn decays to iron with the omission of a beta particle in gamma ray. And scientists have gone up the ladder above uranium creating new elements by hitting the nucleus with a neutron. If the neutron sticks, the atomic weight goes to 239, a new artificial uranium isotope. But the nucleus reacts by getting rid of a negatively charged beta particle, thus raising the positive charge of the nucleus by one and becoming a new element with the atomic number 93 and called neptunium. Neptunium is a malcontent, and it in turn emits a beta particle turning into element 94, plutonium. Even heavier elements have been developed, but we can stop with plutonium because it's one of the basic ingredients of an atomic explosion. In trying to bring about such an explosion, scientists had two recipes, two blueprints to follow. The first called for nuclear fusion. To illustrate here are four hydrogen atoms. If fuzed, brought together under proper conditions, they form one helium atom. But a loss of weight occurs during the process. In other words, the parts are heavier than the whole. Why? Because when the fusion takes place this extra mass, or weight, is converted to and released as energy, energy which might be put to some use. The sun has the key to this combination. It is continually converting hydrogen into helium and sending the resulting energy earthward. That's the principle which might make a hydrogen bomb work. But to the scientists, who wanted a quick solution, releasing a piece of the sun on earth for a moment of devastation seemed a bit impractical. So they went to the upper

end of the ladder and set about getting atomic power through the reverse of fusion by breaking heavy elements into a lighter ones by a process called fission. Like this—when hit by a neutron traveling at a certain speed, the nucleus of a uranium 235 atom breaks up into two much lighter elements with a tremendous release of energy from that which held the tightly packed nucleus together. Like this, while it seems inconsistent that both building up and breaking down of atoms releases energy, this is only possible at the far ends of our ladder of elements. Where a fusion produces energy through the combination of the lightest elements and fission splits only the heaviest, the products of fission and fusion tend toward the middle of the ladder. In the case of fission the possibilities seem immense, unworkable. The scientists knew that the fission of 1 pound of uranium would produce as much energy as the combustion of 1,400 tons of coal, or 250,000 gallons of gasoline. The question was how to do it. How to produce the breaking up of the millions of atoms in a comparatively massive hunk of uranium and do it instantaneously so that instead of a gradual release of smooth power, as demonstrated by a moving locomotive, the energy would be built up then let loose in a violent explosion. A path was indicated by the fact that fission of a uranium 235 nucleus by one neutron creates, in addition to the fission products and energy, two or three new neutrons. Perhaps these neutrons could be put to work in developing a chain rection. This is an example of a chain reaction sustaining itself. This is one that builds up to a big finish. If several neutrons could be produced in a single fission of a uranium atom these neutrons in turn could be used for further fissions, then a chain reaction would be developed which would reach a colossal climax. The energy liberated by each fission step would be let loose in a mighty explosion. They knew that uranium 235 was good fissionable material. They also knew it was scarce. One part in 140 of natural uranium is 235. An insignificant amount is 234 and the rest is 238, which wasn't a suitable, ingredient. It was hard to extract the goods from the bad, because being isotopes both had the same atomic number of 92, therefore, the same chemical behavior. The very slight difference in atomic weights, however, made possible several ways of achieving the separation by physical means. If natural uranium gas is passed along one side of a porous barrier, with a greater vacuum on the other, the lighter 235 atoms will go through the barrier a bit faster than the 238. By this process it is possible to enrich the uranium with the 235 isotope, enrich it enough for fission purposes. The Manhattan Engineer District team of scientists, engineers, industrialists, labor and military, built huge plants to produce the stuff by this and other means. The scientists went further, taking advantage of the fact that uranium 238, instead of fissioning, tends to capture neutrons to ultimately become plutonium. And plutonium is as effective for fissioning as uranium 235.

The Manhattan Engineer District team built a plutonium plant at Hanford, Wash. Our bomb builders were nearing the goal. They had the substance, now for the shape. This isn't it. And the reasons become obvious when we hit the block with a neutron, and follow the careers of the three neutrons we assume are formed by the initial atom split. This neutron enters a nucleus without causing fission. It's captured. It's a dud. These two escape. This is then a hunk of fissionable material in which the neutrons accomplish nothing, and in which a chain reaction can't even get started. It's called a subcritical mass. The problem of the scientists became clear—to make fullest use of all neutrons produced in a single fission. A big step toward their goal was to prevent the escape of the neutrons. Here one of three neutrons makes good. Fissioning another atom and starting a chain. Our material is now called a critical mass. This would be fine for an atomic powerplant but it isn't enough for an explosion. To get that we must keep the birthrate of the neutrons well above the death rate. One neutron must produce two, two must produce four, and so on. Then we'll be in business.

One way to cut down neutron loss and increase the number of fissions is to give them more working room. Yet, since we're dealing with bomb material, we must economize on size. So the best shape is a sphere which has minimum surface area through which neutrons can escape with maximum volume in which they can work and we can further decrease neutron loss by covering our bomb with a special mirror which will reflect the neutrons, turn them back into the field of play. When we get a successful chain reaction going, we have what is called a supercritical mass and our situation is also supercritical because we aren't ready for an explosion. We must keep our supercritical mass divided into subcritical parts until the proper time. When the explosion is desired, the parts are brought together quickly and kept together long enough for a great number of fissions to occur. The time for our bomb to explode is less than a millionth of a second. In building

our bomb, we've been playing a game, toying in a broad general way with theories already worked out in detail and executed by those who during World War II developed and produced the most destructive weapons of all time. Theirs was a dramatic role and a precarious position. They couldn't experiment realistically along the way, they couldn't conduct small, safe, pint-sized tests. There's no such thing as a small, safe atomic explosion.

Below critical size, the bomb is a bust; above, it's a burst. Compromise wasn't possible. To those who early on the morning of July 16, 1945, awaited the setting off of their first atomic bomb, it had to be all or nothing. But which? The The answer left no doubts.

Elementary Physics and Chemistry Underlying the Atomic Energy Program

Mr. Cannon. Dr. Williams, we shall hear from you at this time. I believe you have a paper on elementary physics and chemistry in their relation to the atomic energy program.

Dr. Williams. Thank you, Mr. Chairman. The film you have just seen, sir, is an introduction to the atom and the elementary idea that is made up of planetary electrons revolving around a central sun called a nucleus. This is made up of neutrons and protons generally called nucleons, which are constituents of the nucleus. I will elaborate on the point that this is not the whole truth about the nucleus a little later in my discussion. However, the first point I would like to emphasize, and which was not brought out sufficiently——

Mr. Cannon. If I may interrupt you, Doctor, will you tell us something of your background?

Dr. Williams. I would be very pleased to, sir.

I was born and brought up a Canadian: bachelor's degree, University of British Columbia, 1928; master's and Ph. D., University of California, 1930–31; National Research fellow, University of Chicago, 1931–33; member of the staff of the Physics Department, University of Minnesota, 1933–43; member of the Manhattan District and present at the first bomb test in 1945. University of Minnesota until a year ago. Presently Director of Research, Atomic Energy Commission.

Mr. Cannon. You have never been stationed at Oak Ridge?

Dr. Williams. No. I visited Oak Ridge and consulted there many times.

Mr. Cannon. You may proceed.

CHEMISTRY

Dr. Williams. I would like to emphasize the importance of the planetary or electronic structure of this atom more than was done in the film. Those electrons surrounding that nucleus determine completely the chemical behavior of the atom. The chemical behavior of atoms then further determines the behavior of combinations of atoms called molecules, and aggregates of atoms called solids.

An example of molecules built up by chemical combination of atoms, you have seen here H_2O, two atoms of hydrogen combining with one of oxygen forming water. Another example you are familiar with is sodium chloride, where the exchange of an electron from the sodium atom to the chloride atom forms a bond and forms a crystalline solid sodium. Another example of a solid which is of very great techno-

logical interest today is germanium, a crystal out of which transistors are made. Transistors are those marvelous devices which are presently replacing radio tubes. The electrical conductivity of germanium can be increased by adding a small amount of impurity in a way which can be controlled and determined.

These are examples of molecules and solids which are of interest. As I have said, the properties of these molecules and solids are determined by the electronic structure of the atom. These properties are of paramount interest to the Atomic Energy Commission since all the things it builds and operates and separates and purifies and does other things with are made up of those molecules and combinations of those molecules, called liquids and solids.

Let me explain only this need of the Commission by giving you an example. In order to operate a reactor at the very high temperatures which are needed to propel an airplane or rocket, we must develop solid materials making up that reactor that can withstand very high temperatures and still retain their strength. It now seems reasonably clear that one cannot attain this technological goal by purely empirical methods of cut and try. Rather our hope lies in a further understanding of basic chemistry and solid state science. This understanding has already advanced from a primitive understanding of atomic forces and molecular formation to the point where we can by further experimentation and theory realistically hope to predict what materials could be made to fill this need for high temperature material.

The goals in sight, the extension of our knowledge of the forces between planetary electrons and the nucleus and between one planetary electron and those in another atom is demanded by the practical needs of the Atomic Energy Commission. Those needs have become so urgent and so difficult to satisfy that the present situation is often described as a tyranny of demand.

In addition to the high temperature properties of solids which we need, several other properties of molecules are determined by interatomic forces. One of great interest to the Commission is the dissociation or disruption of a molecule when bombarded by neutrons in a reactor. Such a collision literally knocks parts of the molecules apart just as a marble thrown at a bunch of grapes would knock out one or more of those grapes from the bunch. The bombarded molecules are observed to come apart in specific ways by the disruption of certain interatomic bonds in the molecule. The resulting products may be beneficial. Polymerization of rubber is accomplished; or detrimental results, such as the case of transforming a clean organic fuel into a gummy messy tar. So much for examples of the chemistry of an atom determined by the planetary electrons.

THE NUCLEUS

A much larger part of the mystery of physical sciences lies in the less explored core of the atom, the nucleus. You have seen in the movie that the very small nucleus was thought to be made up of protons and neutrons, called nucleons, closely packed together and closely bound together. It is these enormous forces binding these constituents together which serve as our reservoir of nuclear energy. If we can rearrange a number of neutrons and protons in a nucleus, we can in some cases obtain enormous energy. To understand those

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forces which bind those protons and neutrons together to one another is the ultimate goal of our nuclear physics program.

On the basis of early studies of electrical forces as well as nuclear phenomena, physicists now comprehend not only the structure of the stars, the possible ways of which our universe was evolved, but also matter on a finer and finer scale: from familiar objects to molecules; then to atoms, of which molecules are composed; the internal structure of the atom with its electrons orbiting around the nucleus. The nucleus itself is made up of protons and neutrons, as well as new particles which bind those neutrons and protons together, and lately even something of a picture of the inside of a proton itself, which is complex and containing yet other particles. We are peeling an onion layer by layer, each layer uncovering in a sense a new universe, unexpected, complicated, and as we understand more and more, strangely beautiful.

The present understanding of the nucleus beyond that which you have seen pictured in the movie today leads us to believe that the nucleus is made up of a number of protons and neutrons bound together by exchanging a new kind of elementary particle called a meson. These mesons act as a glue which hold the protons and neutrons together. At the present time we believe this exchange project, which is like a clasping of hands between the protons and neutrons, to be the reason why the nucleus is so enormously stable and why the forces and energies locked in those nuclei are so great.

Our study of high energy physics is directed primarily toward a better understanding of these forces and of the mechanisms which are so fundamental to the existence of matter in our whole universe.

MAKING U^{233}

I don't mean to imply that all our efforts are directed toward looking at a finer and finer detail about the structure of the nucleus. We are also deeply interested and actively busy investigating some of the grosser properties of nuclei, if one can talk about anything being so gross which is so small as a nucleus. We investigate how thorium 232 nucleus is transformed by neutron irradiation into uranium 233. That is interesting because thorium will not suffer fission by slow neutron irradiation, and we are interested in making fissionable material out of thorium. If we can produce uranium 233, then we can see what happens when we bombard it with slow neutrons.

How many neutrons are emitted when uranium 233 nucleus suffers fission? What is the probability of uranium 233 capturing a neutron and not suffering fission? These are the kinds of questions, and more of them, which are intimately connected with a practical question as to whether thorium could be used to breed fissionable fuel, uranium 233, and whether uranium 233 is as useful as uranium 235.

Perhaps I can illustrate that point by using this blackboard for a moment. If we start out with thorium and transform it into a useful uranium 233, we have increased the supply of fuel on the earth. This is one of the forefront problems of investigating the grosser properties of nuclei. If we add a fast neutron to Th^{232}, we get fission. However, if we add a slow neutron, one of low energy in the pile, it will simply be captured, forming thorium 233. This is element 90. We form thorium 233, still element 90. That is radioactive, thorium 90; 233

decays by the emission of an electron into protoactinium. This still has the same mass, 233. Protoactinium 91, 233, decays by electric emanation again, becomes uranium 92, 233.

Mr. CANNON. Off the record.

(Discussion off the record.)

Mr. CANNON. On the record.

Dr. WILLIAMS. This is an example of the work we do at the top end of the periodic table, trying to find out the gross properties of nuclei which will produce new materials which are of potential use in the utilization of nuclear energy.

FUSION ENERGY

As was shown in the movie, I would think we would want to fasten our attention also on the bottom end of the periodic table, the combination of nuclei to produce so-called fusion energy. In this case we can take a reaction in which we add together deuterium and tritium. A heavy hydrogen atom of atomic No. 1 and mass 2, added to the tritium which is a hydrogen atomic No. 1 and mass 3, and produce out of those a helium, atomic No. 2, mass 4, and a neutron.

This reaction then puts together the parts, the sum of whose mass is greater than the end product, and the difference of mass occurs in the form of energy. So for each combination of two hydrogen isotopes we release a large amount of energy. So if one gram of deuterium and tritium reacted in this way in 1 second, we would produce more than one-half a billion horsepower in that second. That would be the power of that engine which chewed up one gram, and a gram is a very small quantity, like this (gesturing). A half a billion horsepower would be the power of that engine.

(Discussion off the record.)

Dr. WILLIAMS. In order to get these together, we must bring them together with speeds which the physicists measure as speeds equivalent to an energy of 100,000 electron volts. An electron volt is an energy of an electron with a speed which is acquired by being accelerated through a tube across which one volt is placed. That is a rather technical description of a measure of energy. I want to introduce it now because the physicist measures energy in electron volts. A slow neutron has one-fortieth of an electron volt. The neutrons in a radio tube may have 50 electron volts. In a small accelerator, 5 million electron volts. An enormous accelerator, 6 billion electron volts.

So our problem is to get these nuclei moving at high speed. In the process of studying the means of getting these together, trying to create conditions on the surface of the earth, we have to create a volume of very hot gas—hydrogen gas with the electrons being stripped from it. We want to know much more about the strange behavior of this new and unfamiliar form of matter in which the atoms are stripped of their electrons, and a collection of atoms as such is called a fully ionized plasma. That is a fourth state of matter. You are familiar with liquids and solids and gases as the three things with which you do business. Here is a new form of matter, one which we have never seen on the surface of the earth, a collection of fully ionized atoms. The understanding of how this matter behaves as contrasted to the formal three states of matter will open up a new technological world.

Basic research into this unexplored area is required and is being carried on as an integral part of our Sherwood program.

NEW FORMS OF MATTER

We have been talking here about the ordinary normal elementary building blocks of matter with which we are familiar. We call them electrons, protons, neutrons. There can be produced in our laboratories, with our high energy machines, for a very short period of time the counterparts of these particles and these are called antiparticles or antimatter. These antiparticles were first observed in our Berkeley lab. They differ from the common particles in having an opposite electric charge. An antiproton has a unit negative charge instead of having a unit positive charge. They have a most remarkable property. Whenever an antiproton and a proton come together, they annihilate one another and disappear, with the release of an enormous amount of energy. The mass being destroyed corresponds to 200 billion electron volts for each collision, which is about a thousand times as much energy as you get out of a single fission event or 10,000 times as much energy as you get out of one of those fusion events (pointing to blackboard).

The production and study of those antiparticles is very meaningful to us in aiding us to acquire knowledge of the fundamental nature of matter out of which everything in the universe is built. The state of our present knowledge is such that we are in the midst of peeling off another layer of the onion. Whether it will be the last layer or not remains to be seen. It would be a rash man who would make any prediction as to what discoveries are to be made, and what immediate practical value they might have. But the one thing we can be sure of, only because physical science research was performed in the past do we have the atom working for us and defending us today. It is reasonable to suggest that the technology of the future atomic energy business will depend entirely upon our basic research programs of the kinds which I have been trying to present to you today. Thank you.

(Discussion off the record.)

Mr. CANNON. That closes your paper?

Dr. WILLIAMS. Yes, sir. Thank you.

Mr. CANNON. I took for granted this was a discussion which could be submitted to the average junior or senior in high school. I see now it is too advanced for those grades. What modifications would have to be made in your paper if it were to be submitted to a freshman or sophomore class in a standard college of arts and sciences?

Dr. WILLIAMS. I would not feel, since I have experience in teaching at that level as well as others, that it would be inappropriate to give them this sort of a talk on their first day as freshman students.

I would hope it would excite them, give them a little insight and lead them to a greater depth of reading.

Mr. CANNON. Thank you, Doctor.

Mr. JENSEN. Let me say, Mr. Chairman, the presentation put on, and the gentleman's paper, of course, are very scientific. He explained the production of the atom, as did the movie. While it is very scientific and technical, at least it proved to me that these gentlemen are schooled in the art, the atom, and that they are devoting their

lives to the problem that we have before us. I wish to compliment the gentlemen who have made this presentation.

Mr. CANNON. Off the record.

(Discussion off the record.)

Mr. CANNON. The committee will stand adjourned until 2 o'clock this afternoon.

AFTERNOON SESSION

DESIGNING AND MAKING ATOMIC WEAPONS

Mr. CANNON. The committee will be in order. General Starbird.

General STARBIRD. Mr. Chairman, my objective is to explain to you the details of how to manufacture a weapon and in addition to that, give you a little idea of the part that the weapons have played in the development of the defensive systems that we now have.

I will follow a four-point outline in this regard, sir. I will first describe the smaller type weapon that we are now manufacturing. I will pass then to the description of a thermonuclear weapon, a weapon which uses fusion in part to get its yield. Third, I will try to sketch out both in the bomb and the warhead field the nature of the bombs and warheads we have had over the last 14 years, and the various systems that develop because of those bombs and warheads. Finally, I will mention certain avenues of approach that we are now pushing, trying to find new things to help us out in our defense posture of the future.

You had a brief description this morning—an unclassified description—of the nature of a fission weapon. This was unclassified and left out many features. On this chart I have shown the critical elements of the more typical fission weapon we are making today.

NOTE.—There then followed a long classified statement, outlining in detail a description of the parts of a fission weapon; the manner in which the weapon components were expected to behave; and the physics involved. Following this there was given testimony as to the complexity in the design and manufacturing of the weapon. It was brought out that this complexity was due to many factors, some of which were as follows:

(*a*) The overall weapon must complete its cycle in an infinitesimal period of time, and on a completely reliable basis. As a result of this every component of the weapon must be the best possible component which can be made, and many are of a radically different nature than any earlier built.

(*b*) Materials must be fabricated to tolerances more stringent than customary for machines and instruments.

(*c*) Some of the materials were toxic and radioactive and had to be worked behind partial or full shielding.

(*d*) Every component in the weapons must be capable of functioning under most severe environmental conditions. For example, from high altitude temperatures many degrees below zero to that of the hotest tropics.

THERMONUCLEAR WEAPONS

I will leave now the matter of the fission weapon and I will pass to the second type of weapon, the so-called thermonuclear weapon. It is a device in which a fission trigger is fired to give pressure and heat, as explained by Dr. Williams, that is necessary to make fusion occur. That heat and the pressure makes a fusion phase of the weapon go.

(Discussion off the record.)

NOTE.—There followed then a detailed classified description of the thermonuclear weapon, also from charts, giving an explanation of the weapon's design features; and the way they were expected to behave. It was explained also that,

in recent years, laboratories have been attempting to develop ways of reducing the proportion of fission in certain weapon designs. The primary long-term contaminant from a weapon detonation comes from its fission debris products. This effort than had as its objective the reducing of the amount of fission debris from a certain yield. Very significant success has been achieved in this regard with respect to certain medium and heavier weight designs.

PROGRESS IN BUILDING WEAPONS

With that background on the design, I would like to pass now to the matter of what has been our progress over the years in the building of weapons. What are the new things that come along.

I will do this using two charts. First the chart that deals with bombs, and then a chart that deals with warheads.

(Discussion off the record.)

NOTE.—There then followed a detailed classified description of the major improvements made in atomic bombs and atomic warhead designs over the years since 1945. In this regard it was brought out that:

(*a*) Bombs initially were time consuming in their preparation for readiness; retained readiness for only short periods; were very massive; and of limited yield. throughout the years improvements have been made which increased the readiness; increased yield; and permitted the development of much smaller and effective designs for tactical use on our lighter aircraft. Also, during most recent years, some designs of the reduced fission type were proven.

(*b*) Most of our advanced missile systems to carry nuclear warheads were made possible in major part by warhead developments achieved through intensive research. This explanation traced the resultant systems from the early ones typified by the Matador and Regulus through the present air defense designs. It extended into the future with regard to certain designs for special uses.

Finally, in closing, I would like to point out those avenues we are looking at now which we feel have a great deal of promise, and which are receiving high priority developmental work.

(Discussion off the record.)

NOTE.—A detailed classified description was given then as to the design improvements of the future which appear of great promise and on which intensive effort was now being placed. These included in part:

(*a*) Further development of small tactical designs which could be deployed with our tactical forces.

(*b*) Extension of the low fission design into the smaller weapons fields.

(*c*) Continual improvement of the readiness and safety of handling and deployment.

(*d*) Warheads to withstand extremely severe conditions and to maximize particular characteristics.

(*e*) Lighter warheads to give additional flexibility and improved readiness.

I might mention in closing, sir, what I have said in this description represents probably the most highly classified information we have in our country, particularly with regard to designs that are concerned. I would be delighted at any time that a committee member wanted to know whether a certain bit of information was classified or unclassified to come and consult with him and tell him, and if necessary, bring our classification people.

I appreciate the chance of describing to you what we have done and what we are trying to do.

Mr. CANNON. Thank you, General Starbird. Are there any questions, gentlemen? Mr. Riley.

Mr. RILEY. General Starbird, as you improve these weapons can you transfer the fissionable material that you have in the other weapons into the newer weapons?

General STARBIRD. This is certainly true, sir.

WEAPONS TESTING

Mr. RILEY. In the development of these lighter weapons, will it not be necessary to continue to experiment with those weapons, and test in order to see whether or not you are approaching your objective?

General STARBIRD. There is certainly a limit to which you can go in the improvement of any weapon without testing it. It is particularly true in the small ones where you are getting down to small features throughout. They are very sensitive and hence really should be tested. We are not able to go a long way beyond where we are now, and where we have design on the board which has been partially tested. We are probably not able to go a long way in designs if one says from a military point of view, am I willing to accept this design? Laboratories may be willing from time to time to forecast that a certain radical improvement, even in the small field, will function right. When one gets to betting the country on those weapons, I think you come to the conclusion that you better stay with something you are sure of, rather than a radical change that you are not quite sure of.

Mr. RILEY. Is there any area in which you can test these weapons without having too much fallout or radiation?

General STARBIRD. Yes, sir. I should say that two things could be done. In fact, three things. In this last test series overseas where we tested large weapons, we tested the designs as far as possible in this clean configuration with the fission greatly reduced. But probably the more important thing with regard to small weapons is that you can fire small weapons underground, and fully contained. We have fired five weapons in this manner. There are difficulties in getting the information you want from the firing. We are relatively certain, however, that we can get information from underground fully contained firings that will let us develop small weapons. Then, of course, it should be theoretically possible to test at great altitude where the fallout in major part would not come back. This latter part of testing is probably the most difficult.

Mr. RILEY. Do you have any intelligence in regard to the Soviet developments of these small weapons?

(Discussion off the Record.)

Mr. RILEY. Thank you very much. Thank you, Mr. Chairman.

Chairman CANNON. Are there further questions?

AFFECT OF SMALL WEAPONS ON SIZE OF MILITARY UNITS

Mr. ANDERSON. There is one question that comes to my mind. General, will the development of these very small atomic weapons change our basic concept of what we consider today as an armored division, for example?

General STARBIRD. Here again, sir, I could only speak from the point of view of personal opinion. The natural thing that would happen if one force had small weapons that it could use would be that the other force would have to thin itself out and spread itself out. I personally am an Army man. I think the Army would still be around. I may be prejudiced.

Mr. BOLAND. Will you yield?

Mr. ANDERSEN. Yes.

Mr. BOLAND. How small is a small weapon going to be? When you get into the smallest of weapons, how small are you getting them? Are these going to be bombs or projectiles from artillery?

(Discussion off the record.)

Mr. ANDERSEN. General, it was your comment previously that set me thinking along this line. Would it change our entire concept of what we consider as a division or regiment today?

General STARBIRD. What I think is that it is going to lead to smaller, more mobile force units. I think this has been stated by the Army and the Marines. There are smaller, more mobile units. They must have added firepower over a period of time, in my opinion, to meet the fact that we are facing every day a more and more immediate threat, that is, a threat that can come on us without warning. So the result will be, yes, smaller units, probably more distantly employed units one from the other, but still having the same basic missions as before.

Mr. ANDERSEN. Just one final question. When do you anticipate having these in supply for the Army?

(Discussion off the record.)

Mr. ANDERSEN. Thank you.

Chairman CANNON. Mr. Jensen.

UNDERGROUND TESTING

Mr. JENSEN. I have often wondered how you could determine the effect of the detonation of an atomic bomb under the ground. Do you explode that bomb in a cavern? How do you go about it? It has always been a mystery to me.

General STARBIRD. There are really about three different forms of finding out what a weapon did. One of them is to look at the fire or heat that came from the weapon. This you can't do underground. The second and probably the best method is to catch some of the debris from the shot and analyze that and see how much of the uranium burned, how much of the plutonium burned. This to some extent you can do by going back afterward and getting samples out of the contained detonation.

Mr. JENSEN. How far underground is this bomb detonated or placed?

General STARBIRD. It would be varied according to the size of the detonation that was expected. If it were 2 kiloton for example, 500 feet in moderate rock should effect the actual containment.

Mr. JENSEN. How can you determine the effect of the detonation of a bomb 500 feet below the ground in solid rock when none of the debris caused by the explosion will come to the surface?

General STARBIRD. As I mentioned, you can go back afterward and drill and get this debris and analyze it. It is not quite as good as if you caught it right away. There is a third method of getting information that I did not mention, and that is to put detection instruments close by which measure the radioactivity and which broadcast the information out.

Mr. JENSEN. We know now what a large atomic explosion will do. We have had enough of them to know pretty well the power of a big explosion. Is the purpose of the Atomic Energy Commission to continue those huge explosions or have we learned enough yet?

General STARBIRD. I think probably this is a question that would be more appropriately directed to one of the Commissioners, sir.

Mr. JENSEN. Very well, but I would like to have it answered. You have not talked much about the huge explosions today. You talked more about the smaller atomic units. An awful lot of people in America and all over the world are greatly concerned about this fallout and we, on the committee, are responsible in some degree at least in finding out and having explained to us just why we must go on, if we must go on, with these huge explosions that cause this deadly fallout material. I think it is one thing that this committee would like to know. I know I would like to know. What is being done to make a clean bomb so we won't have this strontium 90 falling all over the United States and causing greater anxiety and possibly disease among our people? I think it is one of the big things we all have to work together on in order to find and answer. Is there anybody here that wants to try to answer that question? Must we continue to explode these big atomic bombs?

Mr. MCCONE. Mr. Chairman, if I could answer that question, or discuss it. We have, as this committee knows, made very substantial developments and a case can be made for further improvement of those weapons which might require further testing.

(Discussion off the record.)

Mr. JENSEN. But such explosions are very minor compared to the explosions we have had in the past.

Mr. MCCONE. But they, too, can be done underground. Specifically, I think that the developments which are apparent to us now could be done without testing in a way that would contaminate the atmosphere. I would like to add this caveat—that is, that there are new requirements continually being placed before us by the military and a requirement now, not thought of, may be placed before the AEC, which would cause us to reconsider the position I have just stated. However, I don't expect that.

With respect to fallout, I would like to say to this committee that this is a question that gives the Commission and gives me a very great deal of concern. I have discussed with a great number of scientists and people who are knowledgeable in this field. As you know, the Joint Committee has had rather exhaustive hearings; also, our General Advisory Committee has gone into the question in considerable detail. I have reached two conclusions in my mind. One is that all of the tests conducted to date, the Soviets and the British and ours, have not created a condition of radioactivity in the atmosphere and consequent fallout that appears to offer serious danger to the people of this country or the world.

Secondly, it is my opinion that, if testing were continued unrestricted for a period of years, a very serious situation might result. For that reason we have to give a great deal of thought to the future.

In commenting on weapons developments, one of the principal areas of our effort has been in the development of clean weapons. We have succeeded in developing clean weapons in large weapons.

Mr. CANNON. You urge further experimentation and further opportunity for research without limitation?

Mr. MCCONE. No, we do not do that, sir. We feel that the developments of the future are such that if we are to be deprived of those developments because of a restriction on testing, then we must be

sure that the Soviets are likewise deprived of an opportunity of development themselves. We have no ambition to develop these means of destruction just for the purpose of developing them. If we felt that no one was proceeding, then it might be a good thing from the standpoint of the world situation for everybody to stop.

COOPERATION WITH THE ARMED SERVICES

Mr. CANNON. You are cooperating with the armed services to produce lethal weapons?

Mr. MCCONE. Yes, sir, that is our responsibility by law. That is, to develop weapons to meet their specified military requirements.

Mr. JENSEN. I think what the chairman meant is are you asking for unlimited funds to continue research into manufacturing for the manufacture of a cleaner bomb.

Mr. CANNON. That is what I had in mind.

Mr. JENSEN. You are continuing to learn more about how the clean bomb can be produced. Are you not?

Mr. MCCONE. That is correct. That is what we are trying to do.

OPERATION PLOWSHARE

Finally, we place a great deal of importance on the peaceful uses of nuclear explosions known as Operation Plowshare. We think that there is really a very great and important area of development here. Therefore, we think that in any agreement which might curtail nuclear testing, we must not curtail experimentation and development in the peaceful uses of nuclear explosions. We can see the usefulness in innumerable ways ranging from the possible production of oil from shale or from the Athabaska sands to opening up waterways and doing a great many things.

COOPERATION WITH SURGEON GENERAL

Mr. JENSEN. Let me ask you this short question: Is the Atomic Energy Commission cooperating with the Surgeon General and his staff in ascertaining the effect of fallout?

Mr. MCCONE. Yes, we are doing that.

Mr. JENSEN. A bill has been introduced in the Congress to give the Surgeon General greater authority in the control of these dirty bombs, so to speak, and my question, of course, is pointed at just how much more can the Surgeon General do in that respect than he is doing now, if any? You are cooperating with him fully, are you not?

Mr. MCCONE. Yes. We are cooperating with the Surgeon General.

Mr. JENSEN. And he is cooperating with you.

Mr. MCCONE. Yes, and he is cooperating with us. The question of further areas of cooperation and possible transfer of some functions which are now those of the Atomic Energy Commission to the Surgeon General is under active discussion between the Secretary of Health, Education, and Welfare, and myself, and the Director of the Budget as the spokesman for the White House.

Mr. ANDERSEN. Would you yield, Mr. Jensen?

Mr. JENSEN. Yes.

Mr. ANDERSEN. In the final analysis, what you finally determine to do is largely the result of what the Soviet Union does in its line of actions; is that not correct? We must do certain things to preserve ourselves from destruction, in other words, we must have research based upon the need of our national defense. Some of these finer points will depend largely on what our enemy thinks and does, it seems to me, as to how far we should go in our research. I think we have to be practical in this matter.

Mr. MCCONE. I think so long as our military posture and therefore the security of this country and of the free world is cast around nuclear weapons as it now is, then we cannot submit to a position which would permit them to develop unrestricted their nuclear weapons while we do not.

Mr. ANDERSEN. You are absolutely right.

Mr. MCCONE. If we do that, we will find ourselves in this one field on which we are so dependent to be just second best. I don't think we should find ourselves in that position.

Mr. PILLION. Will the gentleman yield?

Mr. JENSEN. Yes.

Mr. PILLION. I certainly agree with what the gentleman from Minnesota is pointing out, that this constant and continual experimentation is fine providing you also have a practical situation where you can use them today or tomorrow.

Mr. ANDERSEN. What I meant is that we must not put ourselves in a position where we have a Munich because that would be disastrous.

Mr. MCCONE. The question of the deployment of it, as to where it is to be located, is a matter for the Defense Department and not us. Our desire to improve that weapon does not mean that we are not going to manufacture the weapon we have. That we are going to do unless there is a directive from higher authority for us not to proceed. But our intention is to proceed with the manufacture of the weapon that we now have developed.

Mr. CANNON. Is there any deterioration of these weapons when stockpiled?

Mr. MCCONE. No.

Mr. CANNON. No appreciable deterioration over any period of time?

(Discussion off the record.)

Mr. RABAUT. Mr. Chairman, may I ask a question?

Mr. CANNON. The gentleman from Michigan.

(Discussion off the record.)

Mr. ANDERSEN. Mr. Chairman, might I ask one more question, please?

Mr. CANNON. The gentleman from Minnesota.

Mr. ANDERSEN. In relation to this large bomb, you are speaking of, suppose it was set off over the city of Washington. How far out would its destruction extend. First its primary destriction, and then from there on.

General STARBIRD. The primary full destruction will extend out a matter of several miles, sir.

Mr. ANDERSEN. That would be complete destruction?

General STARBIRD. This is practically complete destruction. It all depends when you talk about damage the type of structures you are talking about.

Mr. ANDERSEN. I am thinking mostly of life itself.

Mr. CANNON. How does that compare with Hiroshima?

General STARBIRD. The comparison usually goes as the cube root of the increase.

Dr. LIBBY. That is about right.

DESIGNING AND BUILDING NUCLEAR REACTORS

Mr. CANNON. We shall hear now from Dr. Pittman. May we hear you on designing and building of nuclear reactors.

Dr. PITTMAN. Mr. Chairman and members of the committee, I would like to talk from this end of the table if I could, because I can plan to use some slides. You heard this morning a discussion by General Starbird on the uses of the fission reaction to produce nuclear explosives. What I would like to do is discuss with you the use of the same chain reaction that was talked about this morning which is brought about by bringing supercritical masses of uranium together and carrying out the chain reaction. In the course of this discussion what I would like to do is to first develop with you what is a reactor. Second, what are the products of a reactor, the things that we can get out, and third, how we use these products. Fourth, some of the major problems that arise in the development of a reactor system and in building reactors, and then finally to give you as time permits some slides of some examples of the reactors we have developed and we are thinking about in this country today.

In the case of the weapons systems the objective was to assemble the critical mass as rapidly as possible, as General Starbird told you, to hold it there long enough to build up the energy so when it is released, it is released rapidly in an explosive manner. The subcritical masses are assembled in the weapons system very rapidly and brought together as quickly as possible so that the energy is all released at once.

FISSION CHAIN REACTION

I would like to look a little bit in the next slide into something that is quite familiar to you from this morning's movie; namely, what is the fission chain reaction, and try to use this as my basis of the discussion of what is a reactor. This is the basic reaction that takes place in a reactor. This morning we had a moving picture so things could move around. I don't have that this afternoon. In essence, the neutron coming into the U^{235} atom which is fissionable and causing the splitting into the two fragments, and the release of two or three neutrons from that fission.

The slide as shown here shows what can happen to those neutrons. They can get lost. They can get absorbed in U^{238} to make plutonium, as will be discussed in the production discussion later on. Even more importantly, those neutrons can get into another atom of U^{235} to cause once again fissioning. For every neutron going in, we get one out which strikes another. Then the chain reaction is being carried out in a self-sustained manner, and will continue to operate that way.

If on the other hand the neutrons which are released from the fissioning of this U^{235}, if more than one of those neutrons strike U^{235} atoms and causes fissions, then there is an increase in the rate of reaction, and the reaction is on the increase. You will see, for instance, starting at the beginning here on this chart with one neutron, we now have as a result of this three stage schematic system here, six neutrons which have been produced. If these six neutrons all go into U^{235}, then you would get six more fissions, and the thing would rapidly expand.

The problems of a reactor construction are to carry out this reaction in such a way that you can gradually build up to any given level that you desire and hold it at that level of production and prevent it from blowing itself apart. There are several features in a reactor that I can bring out using this slide.

In the first place, you recall this morning there was a statement in the movie, I think, that indicated that these neutrons had to be slowed down in order for them to do their fissioning operation. It is not quite the analogy that I will use, but it is something like this. These materials are vibrating and moving rapidly. The neutron is moving quite rapidly. If you have a very rapidly moving neutron going through that, the chances of it hitting one of these 235 atoms is less than if it is going leisurely through the field. It is like crossing a busy street. If you can get across real rapidly your chances are less of getting run over than if you stay in the street for 10 minutes.

REACTOR OPERATION

The first thing I want to add to this is that, unlike a weapon, a reactor contains a "slower-downer" or a moderator. I won't try to draw anything on this, but if we put in the way of these neutrons a material which will slow those very rapidly moving neutrons down, because they are moving very rapidly as they come out of the fission, then that will increase the probability that they will strike U^{235} and will carry out these operations. This moderator is generally one of the lighter elements. It can be the hydrogen in water, deuterium in heavy water or carbon or beryllium. We have come up with two things necessary for a reactor. First, the fuel itself; obviously you have to have the fuel in order to have the reaction take place. Secondly, the moderator. This morning there was some discussion which I will indicate here about the lost neutron. I think General Starbird in his discussion showed that if you don't have the right shape or size of a critical mass, neutrons tend to get lost. This morning in the discussion there was the indication that you put a reflector around the outside of the uranium to reflect those neutrons back in, so that they will be useful. This neutron, if it were to continue going, would be lost from the field of action if we put at some point out in here a reflector or mirror that will be hit, that brings the neutrons back into the field of action and makes them more readily available.

The third feature of a reactor is thus a reflector. This can be water or beryllium. If it is a very large reactor generally ou don't need one.

Mr. CANNON. Is a neutron ever permanently lost?

Dr. PITTMAN. Yes, it is permanently lost from the field of action by one of several ways. It either gets absorbed in the materials of

construction, like the steel or gets into the shield which I will mention later, or it just gets out and is absorbed in the materials that are surrounding the reactor. Neutrons are absorbed, and once they are absorbed without fission, they are lost.

CREATION OF HEAT

We can cut down on the loss by putting a shield in the system. One thing that happens in the fissioning of a U^{235} atom is the formation as we mentioned earlier this morning of the two fission fragments. Those fission fragments roughly equal in weight and roughly half the weight of the original U^{235} fly apart at tremendous rates of speed. It is the conversion of the kinetic energy of those moving masses of fission product material that account for 83 percent of the heat that is generated in a nuclear reaction. Eleven percent roughly is accounted for by the fact that these materials are produced and are themselves radioactive, and we will see at the end of the discussion here that radioactive materials in themselves are just hot. They give off heat due to the radioactive decay.

A little bit more comes from the fact that these neutrons are being slowed down. The kinetic energy of the neutrons converted to heat.

Finally, something that is not shown on this picture, but which is very important to the reactor system, is the fact that spontaneously with the splitting of this and the formation of these materials which are highly radioactive, there is also the release generally of gamma radiation, something like X-rays, that are highly penetrative rays in themselves as they penetrate the reactor and the reactor material gives off heat. The heat must be removed from the reactor or we will have the situation that General Starbird describes; namely, the building up of large amounts of heat for the destruction of the unit through an explosive force.

REMOVAL OF THE HEAT

In order, therefore, to have a reactor that is useful, you have to remove the heat that is formed by these fissions and that brings up the next factor of the reactor; namely, the coolant. That can be anything you can circulate through the core of the reactor that will remove the heat, and take it outside where it can either be used or dispersed, if you are not planning to use the heat. It can be light water or heavy water. It can be liquid metal. It can be gases. It can be any kind of material which when passing through here has the capability of taking heat away from the unranium and into itself.

So we have then come up with the heat removal material or the coolant, which is another important basic entity of the reactor.

Mr. JENSEN. Your U^{235} neutron is broken up into fission fragments, and that reaction goes on constantly in your bomb when it is exploded?

Dr. PITTMAN. In a bomb what happens is that this keeps on getting more and more. When we started here we had 1 and then 2 and then 3 neutrons and then 6, and then the next time it would be 6 times 3 or 18, and this could just continue rapidly and indefinitely. That is what happens in a bomb. In a fission reactor what we do is to get it so we have the number of U^{235} atoms fissioning that we want

to give us the right amount of heat. That brings me to the next factor of the reactor in answer to your question.

CONTROL MATERIALS

In order to keep this thing from running away, you have to put something in here which will mean that this U^{235} will fission more U^{235}, and this one will fission only one more, and these neutrons will not be absorbed in U^{235} to release more energy. In other words, you have to put something more in to stop this one from getting into U^{235}. This is done by putting material into the path of the neutrons in such a way that they are absorbed in this material. If this ruler represented the material that I am talking about as the neutrons got into the ruler, they would be absorbed and no longer be available for causing another fission reaction to take place. If you did it so that two of those were caught and the third one is not caught, then this fission would give a neutron to hit the U^{235} and cause another one, and you would not be gaining or losing. The materials that we are talking about now are the control materials that are then one of the most important factors of a nuclear reactor. It is the poison that has to be put into a nuclear reactor so that moving it in and out of the reactor we can raise or lower the power level by increasing or decreasing the number of fissions that we get per fission of initial U^{235}.

Mr. JENSEN. At one point is U^{235} completely exhausted?

Dr. PITTMAN. As soon as a neutron hits that particular atom of U^{235} it no longer exists. It is split into two other materials, and the U^{235} itself is gone. So that any time a neutron hits the U^{235} it is gone, or it is burned up, and it has released its energy into the reactor. The control elements in this picture would be an element which, if you were satisfied with two uraniums continuing to fission, you would slide the control rod into the system so that the neutrons would not be available for further fissioning of U^{235}, leaving only this one which would carry the chain reaction on a given level. If you wanted to increase the power level, you would pull this control rod out. You would let two of these cause fission which would raise the number, and further down you would slide it back in again after you increased the level and held it at that point. So a control rod is something you don't have in the weapon. It is something that is absolutely important to the operation of the nuclear reactor.

RADIOACTIVE DECAY

All of these things I am talking about are important but this is the thing that makes it possible to control the rate at which you increase the power, the fact that you hold the power at a given level and the rate at which you decrease the power. I mentioned earlier something not shown on here, that these are radioactive materials. The fission products themselves are radioactive. Further, I mentioned that in the course of the fission gamma radiations are spontaneously released from the U^{235} fission itself. These materials, the gamma rays and beta rays and alpha rays which are given off by the radioactive decay of the fission product, are the deadly materials which you must protect the human being from when working around a reactor. Those together with the neutrons themselves that are in billions and billions in numbers must be shielded so that the people are shielded from their effects.

SHIELD MATERIALS

The last thing we need to make a complete reactor is a surrounding material that is thick enough and massive enough to shield out the gamma rays and the beta rays and the neutrons that are released in the course of this fission so that the people can work around the reactors.

Mr. CANNON. What materials are used for that purpose?

Dr. PITTMAN. There are several materials that are used. Uranium itself is a very good shield from the gamma activity. Lead is one of the classical ones that has been used. Concrete in the big reactors. We use high density concrete with barium sulphate in it. We use iron pellets in concrete. The main thing you need is a large mass of material. As I will mention a little later on in the mobile reactors, that is one of the most difficult problems, to get adequate shielding and still be small in size.

Mr. BOLAND. May I ask with reference to shielding, does the shielding get smaller? Are there ways to make the shielding less massive and less heavy?

Dr. PITTMAN. They are working all the time on getting the shielding down. There is certainly a limit to it. You don't have to have the 8 feet of concrete. In my own opinion you are not going to get the shielding down to a point where its weight will be small enough to have a reactor running your private automobile, or anything like that.

Mr. BOLAND. Are there any substantial improvements in the shielding and massiveness of that since we have been in this field?

Dr. PITTMAN. Yes. There have been a good many improvements in the shielding and the massiveness for the shielding for the aircraft program has come down considerably.

Mr. BOLAND. I have seen that one. It is still really massive and heavy.

Dr. PITTMAN. It is still one of the major problems between this and using this for any small-scale lightweight use where you are going to have to have people in the vicinity of a reactor. It is still a major problem.

SHIELDING FOR SUBMARINE REACTORS

Mr. JENSEN. What is the thickness of the shielding around the atomic reactor in our submarines?

Dr. PITTMAN. Sir, I don't have that figure at my fingertips. It is quite heavy. You can also use another thing in shielding, and that is you can use distance. The shield depends on the amount of material between you and the fission reaction. That material can be air and you can have a long distance of air or it can be lead.

(Discussion off the record.)

Mr. JENSEN. Is that iron?

Dr. PITTMAN. That can be iron. In that particular one it is mostly lead. There might be some iron plates for the thermal shield, too. The trouble is that you have to have some different types of shielding. The main shielding is for the gamma rays. When you have to have a small amount, that is lead. There is also need for thermal shielding and that is where you get water between iron plates. I think there is some of that in the submarine, too.

Dr. FENTON. What is the relative merit between lead and uranium as a shield?

Dr. PITTMAN. Uranium as a shield is certainly more expensive. It is a little more dense. I think what we have to say with regard to the use of uranium as a shield is that eventually the uranium, and this is depleted uranium, the U 238, eventually we hope to develop breeder reactors which will be able to use that uranium as a source of power. So we would not want to be too dependent on uranium as a long-range shielding. We find thus that the major components of the reactor are the fuel, the moderator, the reflector, the control rods, the coolant, and the shielding. In essence, then, a reactor is a very simple gadget schematically. It is something like a wastebasket, a vessel into which you place the fuel elements that release the heat, and around which you have also the moderator materials, into which you have the control rods that drive up and down and through which you circulate a coolant.

FEATURES OF THE REACTOR

The next slide gives this schematically. It shows all of the features of a reactor. We have the uranium rods in the middle that are the fuel material. I have shown the moderator which, in this case, could be water or graphite or other materials. We have the control rods that come down through that core to increase or decrease the power level. We have the radiation shield to absorb these radiations that are coming out of the reactor. Then we have the coolant which in this particular case they have chosen gas as a coolant to be pumped up through the reactor and getting hot. This we have shown going on through a boiler to make steam to go into a turbine situation.

FAST REACTORS

Basically that is a reactor and all of the reactors that we have are quite similar to that particular unit. On the blackboard is a sketch of the Enrico Fermi plant, the plant that is being built near Detroit. I put that on and compare it with this. That is at Monroe, Mich. This does exactly the same. The blue area down there is the core. the coolant tubes showing the coolants going in and out, in this case sodium, are shown. This is a fast reactor and we don't use a moderator. I won't go into the idea of how you can use fast neutrons but they can be used to release fission energy. The reason I want to show this is to give you a feeling of the relative complexity. The top orange section is the top shield to keep the neutrons away from the operating level which is above the floor level that we show there. Basically it is the same type of thing. The only difference is that we have there the lack of a moderator, and in this one I have shown a moderator.

USE OF REACTORS

The next slide shows the three things that all reactors produce. They all produce neutrons. They all produce heat and fission products. There is only one thing to do. There is no way to stop any of the three. I will just briefly go over this one and this one, because other people either have or will cover it. The neutrons can be used to produce plutonium which is the explosive discussed earlier,

or plutonium can be used as a reactor fuel. In one reactor you can produce fuel which can be used in another reactor. It can be used to irradiate material like cobalt and produce radioactive cobalt which can be taken out of the reactor and used as a source of gamma radiation for medical and other purposes. It can then be used as a source of neutrons for the various research programs which require the use of neutrons.

FISSION PRODUCTS

Similarly the fission products, which are really the ashes of a nuclear reaction since they are radioactive, have some uses themselves. We hope as time goes on they will have more and more uses. Again Dr. Aebersold will talk about those.

Two that we have listed as a possibility is the sterilization of food and the initiation of chemical reactions that we cannot carry out by other means at this time.

Mr. CANNON. Your fission products are merchantable?

Dr. PITTMAN. I beg your pardon, sir?

Mr. CANNON. Are the fission products, which you are producing experimentally, merchantable?

Dr. PITTMAN. They are being produced in our production reactors, and they are being essentially stored under the ground. They have more of a negative value than a positive value at this time. I am quite certain that the experimental and research work now going on will make them a positive value in the future. What we are now having trouble handling will later on become a positive value, and have an economic impact on the use of nuclear reactors. At this time they are not saleable.

STORING FISSION PRODUCTS

Mr. RABAUT. How do you store them? Is it in water?

Dr. PITTMAN. The classical way of storing is to have them in solution or in slurries in large underground tanks. There are such tanks at Hanford and Savannah River, and wherever this is chemical processing of the spent fuel that comes from a nuclear reactor. One of the problems of a nuclear reactor that I will mention later is the fact that you don't use all the fuel you put in a reactor. When you get through with a piece of fuel element in a reactor, you still have a large amount of useful material in there, but it has gotten sort of gummed up with materials that are poisons and prevent us from continuing to use it. We, therefore, have to take that fuel element out of the reactor, run it through a chemical separations plant to take out the fission products. Those fission products are stored underground and the uranium that is still useful is put back in the reactor.

USES OF FISSION PRODUCTS

Mr. ANDERSEN. Is there any possibility of making fertilizer or soil conditioners by the use of fission products? Some day we may need more wheat.

Dr. PITTMAN. I think you would not use fission products as fertilizer per se, but you can use them for deinfestation of grain. This is a very good possibility. I certainly hope this is one of the things.

Mr. ANDERSEN. I was thinking if you can sterilize food perhaps you can sterilize soil.

Dr. PITTMAN. There is certainly a possibility of sterilization of soil.

REMOVAL OF FUEL ELEMENTS

Mr. RABAUT. When you separate fission products from the heat unit when it is run down, then you bring back the heating unit by treatment, do you not?

Dr. PITTMAN. I purposely did not mention that there was a little tube that ran down that said fission products and that is probably what you had in mind. You do not get the fission products out of the reactor itself. You have to take the whole element in a reactor out of the reactor and replace that with a fresh element, and take that element to a chemical processing plant where it is dissolved and put in a chemical processing procedure. The uranium is separated from the fission products and the fission products are then stored.

COOLING

Mr. RABAUT. You have to cool it first?

Dr. PITTMAN. You cannot cool it long enough so that it is not radioactive. You cool it from 60 to 90 days to make the chemical processing easier because many of the short-lived products would have died out, and you don't have the mammoth job of separating.

Mr. RABAUT. Does the cooling separate them?

Dr. PITTMAN. The purpose of the cooling before separation is to allow those that have short half lives—you remember it was discussed that some of these decay with a half life of a few hours or days—some after 20 or 30 days for all intents and purposes they don't exist any more. The purpose of that coolant is to allow the short half-lived fission products to decay to the point where you don't have them any more. You don't have to go through the separation of an extremely radioactive material. It is still radioactively hot, but it is not as hot as the minute when you took it out of the reactor.

Mr. JENSEN. Nothing has been said yet about the value of cobalt in a war. I have heard that it is possible to discharge a cobalt bomb which would create a cobalt screen through which a human being could not pass. Would you comment on that?

Dr. PITTMAN. Sir, this is not my competence to comment on.

Mr. JENSEN. Very well.

Dr. PITTMAN. Maybe someone else could comment on that.

FOOD STERILIZATION

Dr. FENTON. How about the food sterilization?

Dr. PITTMAN. The food sterilization is Dr. Aebersold's program. We have been working with the Army which is the group most interested in food sterilization. They are planning and building now at Stockton, Calif., a pilot plant which will use cobalt 60 as the irradiated source. We are furnishing cobalt 60 for them. This is actually an isotope made here rather than one of the fission products. So the problem of food sterilization is most important at this particular moment to the Army, and they are spending the major effort and time in this program. We are working with them only to the extent of furnishing material and helping them with the design of the

reactors. This is a cobalt reactor and not a fission reactor. As far as the reactor development work is concerned, its primary emphasis is on what do you do with the heat that comes out of the reactor. You can use it to produce electricity. You can use it to propel vehicles under seas, on the seas, in the air, possibly through space, possibly on land. You can use it for heating rooms and buildings and other heating requirements. You can also use it for the process heating requirements of industry. The heat that comes from a reactor is in no way different from the heat you get from scratching a match or turning on the gas furnace.

FUTURE OUTLOOK FOR COAL

Mr. ANDERSEN. Doctor, you talk about space heating. How many years in the future do you anticipate it will be before coal is absolutely out of date on account of atomic energy replacing it?

Dr. PITTMAN. I hate to get in the position of being asked to predict on a question like that, but I will try to say this: I don't think as long as we have coal being mined now and the prediction is for many many years in the future that atomic energy will be a replacement for coal. I think we should look at it as a supplement to coal, rather than a replacement.

Mr. ANDERSEN. I am glad to hear that, because there are some people who say that it won't be too long before coal will be out of the picture entirely.

Dr. PITTMAN. No, sir. I think coal is a source of energy this country will need.

Mr. ANDERSEN. In other words, the expense of producing energy will be the medium.

Dr. PITTMAN. Our objective is to put the reactor produced energy in a position where a person building a plant to produce electricity for space heating or other reasons would be able to make his selection on an economic basis, rather than on technical factors.

Mr. ANDERSEN. Thank you.

Dr. PITTMAN. As I mentioned, the heat that comes out is exactly the same as the heat you get from other sources. Therefore, the question comes up, why is it that we are so interested in atomic energy. I think there are two basic reasons. There may be a lot of others but there are two basic reasons, why we are and will continue to be interested in the nuclear produced energy. One is that for the first time in the history of man essentially we have now added to our stockpile of reserves a new type of material that can be used to release energy. It is a material that will supplement the coal, the falling water, the oil, the gasoline, and the other materials that have furnished us energy so long. As time goes on in the future, this additional available source of energy not only to this country, but to mankind as a whole should be an extremely important factor in the lives of the people, not so much to date, but of people in the future, maybe several hundred years from now. In any event, it can be used to supplement coal and the oil and other things we have.

USE OF HEAT

Mr. RABAUT. Haven't you got one other thing besides that? Haven't you got new degrees of heat?

Dr. PITTMAN. That is right.

Mr. RABAUT. That we never dreamed of?

Dr. PITTMAN. We have a new source of material that is a highly concentrated source of energy, and we have the ability to use that to tremendous temperatures that we have not had the ability to do before. Those are the three reasons why we want to look to using the heat in these systems.

Mr. JENSEN. Isn't the fact that it takes a lot of coal or oil or gas to produce an atomic bomb one factor?

Dr. PITTMAN. You mean in separating the uranium 235?

Mr. JENSEN. Yes.

Dr. PITTMAN. That is right. The Atomic Energy Commission I believe is one of the largest users of fossil fuel through the production of electrical current to produce the U^{235}. This is a tremendous amount of energy from the fossil fuel system of the country and are continuing to go into that area. I mentioned something about the highly concentrated source of energy and this is a slide to give you an idea. If we take 1 pound of coal and burn it, we get the equivalent of 3.5 kilowatt-hours of heat for electricity. If we take 1 pound of uranium and completely cause it to be fissioned through the process of being put in the reactor, you get 10,200,000 kilowatt-hours of electrical current. There is the concentration factor that makes this an extremely useful and interesting source of energy. I have back on the table there a piece of uranium that weighs about 8 pounds. That piece of uranium would give us about 80 million kilowatt-hours of electricity and this is a relatively small piece of natural uranium of the type used in the Hanford reactors. Before we get the idea that this is a very simple business—I have tried to show it is complicated from the standpoint of gadgetry and engineering—if we could have the lights for a minute, I have indicated the basic simplicity of the nuclear energy production systems, namely, the reactor. I have indicated that while they are basically simple, they are not quite as simple as you might expect. I have indicated that one of the major advantages to nuclear energy is this high concentration of energy in a relatively small package. I would like now to say a few words about the problems and the disadvantages as we see them today and the problems we have to resolve before nuclear energy is completely solved.

PROBLEMS TO BE SOLVED

It is not completely that way today. For one thing, the units in which you burn this highly concentrated fuel are tremendous units. While we have a highly concentrated source of energy, we have to put it in such large burners or such large reactors to give protection to the people who are using these things that that is one of the problems we have. They are bulky and as a result of being bulky, they

are also somewhat more costly than the somewhat smaller units that you can use to burn coal.

I mentioned earlier that that problem is when you get through with the fuel element in a reactor and when it is no longer capable of giving off more energy, it still has in that element, if put in a reactor, operated for a certain length of time, and then have to be taken out and the fission fragments removed from the material.

Mr. JENSEN. Then will that rod disintegrate?

Dr. PITTMAN. I have a picture in a minute of what happens to a rod when it has been in a reactor for a while. The radiation damage causes it to stretch and swell and bend. One of the major problems is to develop a fuel element which will withstand the very high temperatures under radiation damage and corrosion conditions you have inside a reactor. Those are problems that we are working on all the time because the environs of the inside of a reactor are about as rough as anything you can find. General Starbird had something that was extremely accurate, and they had to develop new systems of instrumentation, but when he got through they were blown apart and gone. We have not quite as bad a problem with regard to the timing but you have to have something that stands up year after year. You are not interested in a reactor that lasts for just a short time. You want it something that you build today and it will be there for 20 or 30 years in operating condition. The corrosion problems where you are handling high temperature gasses going at great rates of speed and water and steam under high temperatures and pressures are extremely difficult to handle. One of our major problems is to get materials that will stand up in the reactor. Not only the fuel elements themselves, but also the cladding materials. The uranium that you see has to be clad. You cannot put it in contact because it reacts with water. One of the best claddings that we have developed has been zirconium. There is a sample of crystal bar zirconium. When I came to the Commission from Los Alamos there was very little zirconium. Today zirconium is used for cladding elements, making tubes and pressure vessels. The material was several hundred dollars a pound at that time.

ZIRCONIUM SUPPLY

Mr. CANNON. Is the supply of zirconium adequate?

Dr. PITTMAN. Yes, sir; it is adequate.

Dr. FENTON. Who is responsible for the development of zirconium?

Dr. PITTMAN. I would say the major development was done by Admiral Rickover for the naval program. Many other people have been working on that, but he had the most immediate need, and responsibility for the development rested with him.

Dr. FENTON. How much research work has been done on zirconium?

Dr. PITTMAN. This zirconium work has been carried on for a long time. The crystal bar process was developed by the workers at the Bureau of Mines many years ago. They have done a terrific amount of work in bringing this system into being, and also using other systems that are simpler and cheaper. The Bureau of Mines, working with the Atomic Energy Commission, have really done the basic engineering work that has been necessary.

Another problem that I mentioned is that you are generating a tremendous amount of heat in a relatively small quantity of material. That is one of the basic advantages of nuclear systems, but it also brings up one of the major problems. You have to get heat out of a small source in a very short time.

Mr. RABAUT. What is the effect of this metal? This forms a sleeve around the unit?

Dr. PITTMAN. Yes. You fabricate that into a canning like a pipe, and put the uranium in, and seal it off. That is highly resistant to corrosion. So it just protects. It keeps the water from dissolving the uranium. It also keeps the fission products released from uranium from getting into the water.

Mr. RABAUT. It separates the water from it.

Dr. PITTMAN. That is right. It is a barrier between water and uranium.

Mr. RABAUT. Is it a heat conductor?

Dr. PITTMAN. Yes. It is also used in the pressure vessels that are necessary.

Mr. RABAUT. It is a new metal?

Dr. PITTMAN. I would say zirconium has been known about 100 years or so, but it is only in the atomic energy program that it has found an industrial application. One of the major problems is that zirconium always occurs with hafnium, which has very bad nuclear properties, because it is a poison to the reactor. So we had to go through the development of a procedure to separate the zirconium from the hafnium, so that you would have zirconium as the material of construction. Then we turn around and use the hafnium for the control rods to absorb the neutrons.

Mr. RABAUT. Is this related to silver?

Dr. PITTMAN. No; zirconium is not related to silver. It is nearer to so-called rare earth materials about the middle of the periodic system. It is metallic like silver, but it is much more resistant to corrosion than silver. It is a considerably heavier material. That is just a piece of zirconium that has not been fabricated. The other piece of uranium that is going around here is similar to the elements used in the Hanford production reactors. I have in the back there some elements that you can look at which show the complexity of making these fuel elements for nuclear reactors. You have to get a large surface so that you can get the heat out of the reactors and out of the fuel elements. So I have here an example of the fuel elements that are used in the experimental boiling water reactor at Argonne. You can see what we have had to do is to try to make plates and put the plates together in such a way that you get a large surface exposed to the coolant. This particular one is an element that goes in the MTR at Idaho Falls. It is a series of plates and the coolant flows up through those plates.

PROBLEM OF FUEL ELEMENTS

Another one of the major problems that we have is to do everything we can to fix it so when we put a fuel element in a reactor it stays there long enough so we won't have to send it back for this complicated chemical processing business. A major part of the Commission's work is to extend the life of the fuel that goes into these reactors. I hope we will be successful. It is one of the most important features of getting cheap power.

Another thing that is very important is to learn how to fabricate these things in simpler and cheaper ways. The ideal way of handling a fuel element would be to do like coal and that is shovel it in. Unfortunately, we have not gotten to that point. I would like to see us get to the point where we can pour it into the tubes, and tamp it, rather than going through the somewhat complicated procedures in fabricating that are necessary. The expense of operation of a nuclear reactor is primarily in the expense of the fuel element fabrication and reprocessing.

DESCRIPTION OF SYSTEMS

I would like now to show the next few slides rather quickly. This is the way a coalpile is used to burn coal to generate steam, steam through the turbine, and the generator to generate electricity, condensed, and back into the system. This is the basic steam-generating plant.

The next slide shows a similar thing. The gray area is exactly the same for this as for the previous slide. This replaces the coal-burning portion of the plant with a reactor. In this case it is a pressurized water reactor. There we have the fuel rods. The water is both the coolant and the moderator. It is in a thick pressure vessel, and therefore the pressure can be raised to maybe 2,000 pounds per square inch, and this hot water is pumped through a heat exchanger in which other water is converted into steam and then into the generator, and on out. This is a simple schematic diagram of the unit used in Shippingport, and in the submarines, and many of the reactors that are being built today.

The next slide, please. This is a similar slide showing the boiling water system. The same thing here, the fuel elements and moderator and coolant, but this time instead of having the pressure so high that you are pumping, you allow the water to boil and the steam goes directly from the reactor into the generator and back into the system. This is similar to the system the General Electric Co. has built at Vallecitos and the one at Argonne.

Mr. ANDERSEN. Is there any loss of water?

Dr. PITTMAN. There is always a little loss of water because these are not completely tight. One of the problems in developing atomic energy for the reactor business is to develop pumps and motors and valves and all the appliances that go with this material that are tight. In this case it is not too important because the material that comes over here, the steam is not radioactive. In a minute I will show you a place where it is.

SODIUM GRAPHITE REACTOR

The next slide. This is an example. Here is a sodium graphite reactor, similar to the one we have built at Santa Susana by North American. Here are the fuel elements and the graphite moderator in a pool of molten sodium. The sodium becomes radioactive. We are pumping that radioactive material out of the reactor itself through a heat exchanger. That heat exchanger picks up the heat from here and carries it to another heat exchanger where steam is made and goes into the system. In this system here it is certainly an extremely important problem to have valves and pumps and pipes and things

that don't leak. If they do leak, you are drizzling radioactive sodium all over the place.

Mr. RABAUT. You have the element there. What is in between?

Dr. PITTMAN. This is the element and this is the graphite which is the moderator. There is no water in this system so you have to have another moderator.

The next slide shows three other systems. For coolant, you can use something like oil. We have used a material that actually when it is at room temperature is something that looks like wax, but when you melt it, it becomes a liquid. Here you see the fuel element. In this case the organic material, the oil is the coolant and the moderator. It does not boil because it has a higher boiling point than water. It can be pumped through a heat exchanger to make the steam that goes into the generator and then back into the reactor. This is the type of reactor on which we have an experiment out at Idaho Falls underway.

Mr. RABAUT. How do you arrange the size of the heat exchanger? There must be some sort of mathematical formula.

Dr. PITTMAN. The size depends entirely on how much heat you want to take out of it. If this is to be 100 megawatt system that is calculated.

Mr. RABAUT. And then it takes the size you feel you should have?

Dr. PITTMAN. The whole system is designed at once so you design ahead of time how much power you will take out of the fuel. Generally because we have found from experience that you get more out of a reactor than you calculate originally, you design your components so that they can take more heat. You design your heat exchangers with maybe 50 percent extra. It is the cheapest way to get more power out of a reactor. It would be a shame not to have this thing sized accordingly.

Mr. FENTON. That generates the heat?

Dr. PITTMAN. It generates the fission products but they are all contained in these materials. None of the radioactive material gets over here at all. The organic material does not become radioactive.

Mr. ANDERSEN. Don't you have to have a shield around that pipe leading off?

Dr. PITTMAN. This has to be shielded right to here. The pipe from there on out is not radioactive.

Mr. ANDERSEN. What about the outlet?

Dr. PITTMAN. Your shield comes down here and, to keep from having a radiation shine, you do have a zigzag path for the pipes to go through. The material itself is not radioactive. You do have the problem of direct shine if you don't zigzag pipes. Here is just a schematic of a gas-cooled reactor in which you have the fuel element, the moderator which can be graphite or heavy water or beryllium. In this case you pump gas—it can be air, nitrogen, helium, carbon dioxide, or other gases—through the reactor; those gases heat up and go back directly through a gas turbine machine, or you can send them through a heat exchanger to make some steam. The liquid metal reactor is an example of the type of reactor that uses the fuel in solution or in the molten form. The fuel here is contained in the material that is also the coolant. You dissolve uranium in this case in bismuth or molten salt, and then you pump that solution, containing all the fission

products, right through the system like that, into a heat exchanger which in turn takes the heat out of a fuel and puts it into a secondary heat exchanger, and then back into the system.

The next slide, please. I thought here it might be interesting just to show the difference.

Mr. CANNON. If the gentleman will permit us, a vote is coming up on the floor. We will all have to answer rollcall. We will not get back in time to resume. Accordingly we will discontinue now. The committee stands adjourned, subject to the call of the Chair.

MONDAY, JUNE 22, 1959.

Mr. CANNON. The committee will be in order. We will resume with the orientation program.

At the time we last recessed Dr. Pittman was discussing nuclear reactors. The chair recognizes Dr. Pittman to continue his discussion.

Dr. PITTMAN. Thank you, Mr. Chairman.

Can we have the first slide?

You will recall last time I mentioned that the core of the reactor undergoes very severe conditions. All I want to show here is what happens to the piece of uranium of the type you saw when it is exposed to the reactor, to the condition in the reactor.

Notice the stress. This slide indicates that things do happen in a reactor which is pretty severe.

Here is another example of what happens to the nice cylindrical piece of uranium you just saw. It goes into all sorts of shapes. This is just an indication of what happens when a core does melt down. Here is a picture of an EBR–1 core which was melted down a couple of years back. All of these uranium rods were melted.

Mr. JENSEN. What caused that?

Mr. CANNON. Off the record.

(Discussion off the record.)

Mr. JENSEN. What caused that condition? Did you have an explosion?

Dr. PITTMAN. There was no explosion on the things. That is, what happened, these elements were being cooled by the molten sodium between them. The sodium could not get between them. They were so close together and so much heat generated they could not be cooled.

Mr. JENSEN. That effected every one of the bars?

Dr. PITTMAN. Not all of them. That affected all of them in the section we show.

Mr. JENSEN. All of those were worthless from then on?

Dr. PITTMAN. We shut the reactor down. The core melted and the uranium ran away from the center of the core and the reactor shut itself down because there was not enough uranium to continue to have a critical mess. That uranium can, of course, be recovered and be reused.

This is just an example of the core which we showed last week. This is the MTR core in which plates of uranium put together this way are sandwiched between aluminum alloy and placed in an aluminum holder of the fuel elements.

This is just another example of the way fuel elements are made in which uranium is in the red section and is in concentric rings. It is another way of getting a large area through which the coolant can flow.

This is just another example of the way we pack the fuel elements together.

REACTOR CONCEPTS

Here is an example—the rest of these are just pictures of reactors that we have had at one time or another built or thought about. This is the swimming pool reactor of the type the universities are building. The reactor core is down in the water. The control elements run up and down. The water by itself, its natural circulation, cools that particular reactor. It is a research tool that can be used by the universities.

Mr. JENSEN. We saw one of those at Calder Hall.

Dr. PITTMAN. Yes, sir. There are quite a few of these around the world.

This is just another example of the training reactor which was meant to be the Argonaut, this is to put experiments down into the reactor.

This shows a graphite thermal column, where you can get highly thermalized neutrons out of the reactor.

This is a slide which is the core. This is really the working part of the experimental boiling water reactor out at Argonne. I have shown this to give you an idea of the size. The core is about 7 feet tall. This is the core of the reactor. That is what basically makes the work.

This is the schematic of the same reactor. The core of the reactor in this case is in here, in its containment vessel. This is the relationship of the reactor itself to everything that is necessary to make the reactor work. It shows the sphere that surrounds the reactor to contain the fission products that might be released in the event of a meltdown accident that might take place in the reactor.

The next slide shows the picture of the same reactor. This slide shows a reactor experiment which was built out at Idaho Falls. It is the experiment in which we have first proven that organic material like oil or wax can be used to cool the reactor in place of water or molten salt or sodium. This particular experiment was run for one purpose only and that was to determine what would be the effect of radiation on organic material. It was a very successful reactor experiment and has led to the whole organic cooled reactor concept.

This is the picture of the sodium reactor experiment out at San Susana, Calif., operated by North American. It is a sodium graphite reactor which furnishes about 5 megawatts of electricity.

This is the core of the Shippingport reactor. Again, just to give you an idea, this is the basic unit that gives off the heat that is converted into power. Again, you can see the men standing there and it gives you an idea of the size of the core.

This is just an overall picture of the Shippingport reactor.

This is a schematic view of another thing which can be done with reactors. It is a schematic of the *Savannah*, the reactor being down in here in a completely contained steel vessel to drive the turbines that drive the screws of the *Savannah*.

This is just a mockup of the reactor which is in the *Savannah*, to give you an idea of the size of the containment vessel and the reactor vessel itself and shows a man so it gives you an idea of the size.

This is a picture of the Army package power reactor located at Fort Belvoir. It is a small pressurized water reactor. It is one of the many that will be built for the armed services.

Mr. JENSEN. How long has that reactor been in operation?

Dr. PITTMAN. It went into operation about 2 years ago.

Mr. JENSEN. Has it been completely successful?

Dr. PITTMAN. Yes, sir; that has been a very successful operation.

Mr. JENSEN. You have had no incidents whatever?

Dr. PITTMAN. None.

Mr. JENSEN. Have you changed any of the fuel elements?

Dr. PITTMAN. They have changed the fuel elements; yes, sir.

Mr. JENSEN. Some of them have exhausted all their power?

Dr. PITTMAN. Some of the full elements have been taken out. In running an experimental reactor you take fuel elements out before tyey have actually become exhausted because you want to see the process of exhaustion as it goes forward. So in these initial experimental reactors you don't wait until they have been exhausted before you take them out. This is a 10,000-kilowatt unit.

Mr. JENSEN. It has been completely successful?

Dr. PITTMAN. It is a successful reactor. Of course, it had its bugs and startup problems like any other reactor.

Mr. JENSEN. That power is run to a grid?

Dr. PITTMAN. That power is used at Fort Belvoir. There is a thermal generator in the reactor building which produces the power. Here now is an artist's conception of the low-power reactor that we have built out at Idaho. The core of the reactor, this whole reactor is contained in a steel vessel. Even the working areas and the reactor is a very low-power boiling water reactor down under grade. This is one which is capable of being used at remote sites and is easily transportable.

This is a picture of a cutaway of a typical reactor. I happened to take the plutonium recycle test reactor at Hanford. You see the relatively small size of the reactor in comparison to things that have to be built to make the reactor operate and to do all the things you have to do around a reactor, such as taking the elements out, putting them in a storage bin, and letting them cool down.

This is a schematic of something we are quite interested in. It has to do with the building of a reactor in a very compact manner and placing it in a barge so that it can be moved around from one installation to another. This reactor is not meant to drive the barge. It is a barge-mounted power reactor which can be towed and used at different places.

This is an idea of a compact reactor where the reactor is small, gas cooled, using air so you are not dependent on source of water for your coolant.

This is a picture of the *Nautilus* and *Skate*. These reactors are pressurized water reactors and have been very successful.

This is a picture of the Kiwi A reactor. It is an actual mockup of the one that was placed in operation and carried in the press last Saturday.

This reactor is being used to study propulsion of rockets. Obviously, this is a large unit. It will not take off. That is why it is called the Kiwi. This is to give you an idea of the size of this particular unit.

Mr. JENSEN. How many kilowatts?

Dr. PITTMAN. ———

(Discussion off the record.)

This is a picture of the heat transfer experiment No. 1. It was the initial testing of a reactor that was used to test the direct cycle for driving turbines for the ANP program. The reactor itself is a rather large unit. The air coming up through here and out through these turbines.

This is a schematic of the "Tory" engine. The reactor back here, the air coming in.

That is the last slide. I have around here some of the exhibits we had before. This is the element that is going into the experimental breeder reactor No. 2. I showed you pictures of the meltdown on experimental breeder reactor No. 1.

These are sections and pieces.

Mr. JENSEN. Do you have any samples of plutonium?

Dr. PITTMAN. No.

Mr. JENSEN. What does it look like?

Dr. PITTMAN. Plutonium looks very much like uranium. It is a brittle, silvery metal which it has until after it has been exposed to air. It is unhealthy to handle. You don't generally have it and pass it around. It has alpha activity and it is better not to get into it.

This is an actual mockup of the "Snap 2" reactor. This is the exact size of the reactor. The reactor core is down in here.

Mr. JENSEN. For what purpose?

(Discussion off the record.)

Dr. PITTMAN. The operating "Snap 3" which is run on isotopes is shown there. If you would like any kind of explanation of this, we can give it to you.

This is the next one, which is something you saw last week. It is another fuel element section. This particular one for the experimental boiling water reactor. I have shown a picture of where these sections set down in the experimental boiling water reactor. You saw pictures of the size of it, 7 feet tall.

The next is the cutaway of the Army package power reactor. The core is shown down in the middle there.

Mr. JENSEN. What did you call that?

Dr. PITTMAN. The Army package reactor at Fort Belvoir. This reactor uses a method of fuel follower control not used in too many reactors. Not only do you put the poison in it that absorbs neutrons, but in so doing it also removes pieces of the fuel element.

You can see that working up and down. When it is in the up position the fuel is in. The black is a piece of the fuel. When it goes down the fuel goes out of the reactor and the control element comes into the reactor. It is a double control. It is also fixed so that a failure causes the fuel to drop out. It is a fail-safe device.

In the event of electrical failure the fuel drops out and control drops in and it shuts the reactor down.

ISOTOPE UNITS

The next two units are the Snap 3 isotope units. This is the one that was shown to the President; at the time it was shown several

months ago it was operating 2½ watts. Since then the isotope, which is in here— I believe polonium—has decayed so it has only half the power as at that time. Still several months later it is capable of driving that little fan.

This is a dummy that shows how the isotopes are placed in the little tubes and the heat all comes from the decomposition of the radioisotope and it is converted to electrical current through the thermoelectric phenomenon. It is a completely contained unit.

Mr. JENSEN. The parts that we see in there, there is no action whatever, no mechanical action.

Dr. PITTMAN. No, sir; no moving parts. This is nuclear action. It is the nuclear decay of the isotope which is in there that causes heat to be liberated. The heat in turn, is converted directly to electrical energy through the phenomenon known as thermoelectric conversion.

That, sir, is all I have to say.

Mr. CANNON. Dr. Pittman, how long have you been in the field of Federal service?

Dr. PITTMAN. I entered the Federal service, sir, in 1948, in June of 1948 with the AEC.

Mr. CANNON. Have you been assigned to this work ever since that time?

Dr. PITTMAN. I have been with the AEC since then. I came to the Production Division in 1948. I stayed there until about 1955 at which time I went into licensing and civilian application and transferred to reactor development just a little less than a year ago, sir.

Mr. CANNON. Where have you served since 1948. Where in the United States?

Dr. PITTMAN. All here in Washington with the Atomic Energy Commission. Before that I was at Los Alamos during the war, doing plutonium work out there.

Mr. CANNON. Have you visited plants over the country?

Dr. PITTMAN. Yes, sir, I think I have visited most of the plants.

Mr. CANNON. Did you come to Federal service direct from school?

Dr. PITTMAN. I was in Los Alamos for 4 years during the war. My last job there was as manager of the plutonium production work at Los Alamos.

Mr. CANNON. Where was your work done?

Dr. PITTMAN. At Vanderbilt University.

HIGH ENERGY ACCELERATORS

Mr. CANNON. Dr. Williams, will you take up high energy accelerators?

But first, what is the function of the accelerator?

Dr. WILLIAMS. The accelerators which we show you visually here by means of this movie are to speed protons or electrons to very high energies so that they may disintegrate nuclei, that is, take them apart to see how they are made.

Mr. CANNON. Accelerators are tools of science, then?

Dr. WILLIAMS. Yes.

Mr. CANNON. Where was your undergraduate work done?

Dr. WILLIAMS. At the University of British Columbia.

Mr. CANNON. How long have you been in the Federal service?

Dr. WILLIAMS. A little over a year.

Mr. CANNON. You came directly from British Columbia?

Dr. WILLIAMS. No; I came directly to this position from the University of Minnesota where I have been on the staff of the physics department for about 25 years.

Mr. CANNON. Are you a naturalized American citizen?

Dr. WILLIAMS. Yes, sir.

Mr. CANNON. You may proceed.

Dr. WILLIAMS. Because of the complexity of these devices and the machines themselves as well as the equipment with which the experiments are done we have chosen to present to you visually about 13 minutes of a movie made originally to show at the Geneva conference on the peaceful uses of atomic energy. From this movie then, you will see the two accelerators which are operating in this country, in the United States, at energies of 3 and 6 billion volts and some of the equipment that uses them.

(The movie referred to was then shown.)

Mr. CANNON. Are there any questions?

BIOMEDICAL ASPECTS OF ATOMIC ENERGY

Dr. Charles L. Dunham will discuss something of more immediate interest to us, the biomedical aspects of atomic energy.

Dr. DUNHAM. I have a few charts I would like to use during my presentation. I am going to try to give the committee a little feeling for what radiation does to matter and what we are trying to do about this, and also a little about the peaceful use of atomic energy in medicine and agriculture.

Mr. CANNON. Might I ask you there, completely off the record.

(Discussion off the record.)

Mr. CANNON. On the record.

NATURE OF ATOMIC ENERGY

Dr. DUNHAM. Atomic energy is like fire. We use fire to heat our homes. We use it to speed chemical reactions, to smelt metals. We use it in war. We killed 70,000 people in Tokyo during World War II with fire only. Atomic energy is the same sort of thing.

You can use it carelessly; it does not burn your house down but it may cause cancer. On the other hand, we use X-rays to diagnose cancer. We use X-rays, radium, and radioisotopes, all forms of atomic energy, to treat cancer and in some instances we actually cure cancer with radiation.

RADIATION EFFECTS

The two principal effects we worry about are cancer and the genetic effects. These are long-term effects. They do not occur immediately after exposure. Now its hazard depends on two things associated with the source of radiation. One, the penetrating power of the radiation and, two, the chemical behavior of a radio element if it is introduced into the body. The latter determines where a radioelement will go. Radium we know goes to the bone. This is what happened in the radium dial industry. Plutonium goes to the bone. We see

to it that our workers do not get too much plutonium in them. Radiostrontium in fallout goes to bone. The gamma rays and X-rays are very penetrating. They can pass through the entire body. This is the way that X-ray pictures are taken, of course.

BETA RAYS

Beta rays, which are the principal radiation that we worry about in fallout material from the standpoint of it getting into the body or in contact with the body can only penetrate in a body a matter of a few sixteenths of an inch at the most.

If much of this material gets on the skin and remains there, burns result. It occurred with the Marshall Islanders and the Japanese fishermen in 1954. Alpha radiations are the principal radiations from plutonium, they cannot penetrate something as thin as this piece of paper.

Dr. Pittman passed around a great big hunk of uranium and you handled it and it did not harm you at all. On the other hand if you had that much uranium deposited in your bones, it would do quite a bit of damage.

With the gamma emitters, then, we have to shield them, put heavy masses of material between us and them and the same is true of the neutrons. We must, of course, avoid contact with them.

With the beta ray emitters we must keep a reasonable distance away, at least a few inches away from them or else shield against them. With the alpha particle emitters we must be careful not to breathe them, eat them, or get them in a wound because eventually this sort of thing will lead to deposit in the bone.

Now, the reason we as a division are so interested in people who have radium, that is the dial industry and the patients who receive radium for treatment of disease, is that we want to know how much radium it will take to cause cancer of the bone. This will give us better information as to what the permissible body burden of radium is.

DETERMINING RELATIVE RADIATION HAZARDS

We have experiments going on which are comparing the relative hazard from radium, plutonium, strontium 90, and thorium. Knowing what the hazard is in humans, when these dog studies which are quite extensive and which take 15 years to complete, when the results are all in we will have a very good idea of what actually is a permissible body burden for any of those elements in the human body.

To show you how we go about this I have a picture here of the whole body counter at the Argonne lab. This is the operator sitting outside the iron room. This young lady is the subject. She has just taken a shower. She has just put on a clean gown. She will go inside this counter, which is in an iron room which is several inches thick. The walls are made of actual battleship plate to keep out natural radiation. Inside the room she sits in this chair in this position. Here is the crystal which counts the radioactivity. Here is what the operator sees on the dial. This procedure will tell us exactly how much radium she has in her. It will tell us how much radio-

active potassium she has in her. It will tell us how much radio cesium she has in her.

It will not tell us how much radio strontium she has in her.

Mr. CANNON. Is the lady a patient?

Mr. DUNHAM. She is a radio dial worker who has ingested in her work an unknown amount of radium. We are trying to find out how much she has in her so if some day she dies of bone cancer we will have a record. When the score is all in on these people then we will know what is the smallest amount of radium in any human being that ever produced a bone cancer.

USE OF DOGS

Mr. MAGNUSON. In the experiment with dogs, are you foreseeing that these dogs are going to live for 15 years?

Dr. DUNHAM. The ones with high doses are dying already. We are interested in the ones who live for 15 years.

Mr. MAGNUSON. That is a long life for the dog.

Dr. DUNHAM. We have a hunch that the last dog may live as long as 15 years from birth.

The average life of a dog is 7 to 10 years. Every time you set up a biology experiment nature has a way of fooling you, so we are not assuming that this particular experiment will be completed for close to 15 years. At least it won't until the last dog is dead. There are about 400 dogs involved.

Mr. JENSEN. This last dog that you hope will live 15 years, has he been subjected to this experiment since he was a pup?

Dr. DUNHAM. In this particular experiment, the first one started at Utah, they got the radium at the time bone formation stopped. In other words, these dogs were comparable to an adult human working in a radium plant, not to children. The other experiment, underway now at Davis in California, actually starts with giving the strontium to the mother and as soon as the infant or pup is born strontium is introduced to the pup and from then on for the rest of its life, keeping the amount of strontium in the dog or radium as a comparison constant at all times.

Mr. JENSEN. Do you think there may be some dogs that will live to be 15 years old under those conditions?

Dr. DUNHAM. At these very low doses, it is quite possible.

Mr. JENSEN. What do they average? Dogs hardly live to be 15 years old.

Dr. DUNHAM. No; but when you have 500 dogs in an experiment I think you have to assume that one may live that long.

Mr. JENSEN. Are you trying to prove that the effect of this stuff in the dog will not lessen the life if it does not receive too heavy a dose?

Dr. DUNHAM. We are trying to find out exactly what will happen at the different dose levels. I think it is quite likely on the basis of experiments in mice that the low-level animals will show no effect whatsoever but we want to be sure in an animal that is more like a human in its dietary habits and is a much longer lived animal than a mouse or a rat; your experiments can only run a couple of years in those animals.

GENETIC EFFECT

Now, the other effect that we are particularly interested in is the genetic effect. This shows up as abnormalities in descendants of people whose germ cells have been irradiated and they are of particular concern to us and to the people who have to develop the permissible levels of radiation exposure.

Recently, at the Brookhaven National Laboratory some of the people working as a team labelled the amino acid thymidine, with tritium which is a radioactive form of hydrogen. This material was introduced into some germ cell material and here, actually forl the first time in history (these little black dots here is where the tritium is) represents actually labelling of the genetic material.

One can follow this through several generations and see how this labelled genetic material behaves.

I might mention that at the Geneva Conference this summer there were six papers from different foreign countries all using this technique which was developed at Brookhaven. It has been a real breakthrough in the field of genetics.

Now, one can protect against radiation in two ways. The most effective way, of course, is to stay away from it or by placing some dense material, earth or concrete, between yourselves and the source. Actually, of course, we are all somewhat radioactive from the natural radio potassium, radio carbon, and radium in our bodies.

Furthermore, the earth itself and most of the rocks are radioactive, containing small concentrations of uranium, radium, radio potassium, radio carbon, and of course, more recently, radio strontium.

Finally, we are being bombarded with radiation from outer space, from cosmic rays at a time when we are breathing radon gas in the gas we breath. This radon gas is given off by the radium in the earth which is constantly rising into the atmosphere.

CAPACITY TO WITHSTAND RADIATION

So it is fair to say that the human race is used at all times to some amount of radiation. In fact, it developed in a radioactive environment. For a person to be free of all sources of radiation, both internal and external, would be an extremely abnormal state of affairs. Local areas of the body are not usually seriously affected by 1,000 or more roentgen units if received in divided doses as in the treatment of cancer. On the other hand, if the entire body is exposed to several hundred units of radiation all at one time, the individual becomes very ill and may die and this as we have already mentioned happened in Japan and to about 150,000 people. There have only been three fatalities in our own program from the beginning. A great deal of work is being carried out in the Commission, also in the military, and in the Public Health Service laboratories to develop methods for increasing resistance to radiation injury and to treat it.

ACCIDENT AT LOS ALAMOS

Mr. JENSEN. Doctor, will you give us an idea of what caused the death of those three people at Los Alamos?

Dr. DUNHAM. An overwhelming, almost instantaneous dose of radiation.

Mr. JENSEN. Was it the result of negligence?

Dr. DUNHAM. It was the result of an accident. In the first two cases a criticality experiment was being undertaken in the development of the atomic bomb. Certainly, it was not due to negligence. In the recent accident, as in all serious accidents, there were a series of things which seemed to lead up to this particular criticality experience. There is no question but what if everything had gone exactly as had been planned and so on and so forth, the accident would not have occurred. In that sense, it was the result of human failure.

Mr. FENTON. How long did he live?

Dr. DUNHAM. Thirty hours. He had a very high dose. Much higher than the accidents at Oak Ridge, for instance, where nobody died, three or four times the dose.

Mr. JENSEN. Will the death be caused by breathing in this poisonous stuff or simply by the radiation into the body?

Dr. DUNHAM. There was no contamination in this case. It was all contained in the vessel; that is, the actual reaction that produced the radiation. Death was caused by heart failure. In this particular case there was a very high dose and, because of the position of the man, his heart and the region of his chest got the biggest dose. Presumably, there was edema of the heart and this caused heart failure.

Mr. JENSEN. The radiation from the radioactive material penetrated his heart and caused his death; is that right?

Dr. DUNHAM. Yes; a very large dose.

General LEUDECKE. I think he is inquiring as to the nature of the biological damage.

Dr. DUNHAM. That is right; it is a very rapid destruction of cells. They have taken photographs of cells almost literally exploding with high doses of radiation.

Mr. JENSEN. Is it an overdose of radioactive material that causes the death rather than the breathing in of radioactive atmosphere?

Dr. DUNHAM. I know of no fatalities which are the result, I mean immediate fatalities, which are the result of inhaling. It is conceivable that if a person got a very large dose of tritium gas, inhaled it, that he could produce the same sort of effect as happened in this accident at Los Alamos. He could get edema of the lung and the individual would suffocate, but that would be a fantastic situation. Such a thing has never happened.

Mr. JENSEN. Off the record.

(Discussion off the record.)

ACCIDENTS ABROAD

Dr. LIBBY. Do you want to remark about some of the accidents abroad?

Dr. DUNHAM. This accident in Yugoslavia was one in which the reactor was operating; the people working about it were not aware that the reactor was operating, for several minutes. There is some reason to think that some of the automatic devices that should have warned people were not working at the time.

Anyway, over a period of several minutes these people received a very high exposure, somewhere between—five of them—between seven or eight hundred rads or roentgen units, up to 1,100.

The individual who died on about the 35th day received about 1,100. The rest of them are apparently surviving very nicely.

SUSCEPTIBILITY OF INDIVIDUALS

Mr. TABER. Does it make a good deal of difference about the individual person; that is, if one person is more susceptible than another?

Dr. DUNHAM. On the basis of animal information there is a great deal of variation from individual to individual. We do not know in humans because every single person that we know anything about who has received a high exposure has received a different dose, but we would expect it.

Mr. TABER. For instance, I heard of a young man who was taken into the Army who was given the job of reading charts that showed the location of planes and ships down at Fort Monroe. He became afflicted with—they called it radio poisoning at the time. That is 7 or 8 years ago.

Dr. DUNHAM. Did he get cataracts of his eyes?

Mr. TABER. He did not have cataracts, but he became blind.

I am wondering, that is the same ingredient, I assume?

Dr. DUNHAM. No; that is different from what we refer to as "ionization radiation." That is short wave radiation associated with radar installations. There have been instances of damage to the eyes, but it is not the same thing that we are dealing with in atomic energy.

Mr. JENSEN. Do you want to talk on the progress being made in curing some of these dread human diseases, including cancer, with radioactive isotopes?

Dr. DUNHAM. I would like to talk about that a little later, but I would like to talk a little about what we know about how we treat whole body radiation injury.

Mr. FENTON. Just how far does Yugoslavia participate in a program of this sort?

Dr. DUNHAM. I would not know of any participation of Yugoslavia in the U.S. program other than what we have learned about radiation injury from their own accident case. They have given us that information. I think it was a Russian reactor, but they have not participated in our program directly or indirectly.

PROTECTIVE TREATMENT PRIOR TO EXPOSURE

We have known for a number of years that if you treat an animal just before he is exposed to radiation with a nearly fatal dose, say, of alcohol, or female sex hormone, hydrogen cyanide, cysteine, or other related compounds, an animal can survive about double the usual dose.

The problem now is to find some substance which humans can take in a safe dose in advance of exposure to radiation. This would be very helpful during war or during an emergency where people had to deliberately expose themselves to large levels of radiation.

Unfortunately, we have no such compound yet and the amount of alcohol which will protect the mouse is very nice but if you gave the same corresponding amount to a man it would kill him.

Now, we also know that living cells from the spleens of baby mice, if injected into animals or mice after they have been irradiated, the mice will also survive about twice as much radiation as had been expected.

If this way we have been able to save the lives of many rodents, rats, rabbits, guinea pigs, and also Rhesus monkeys. We are not sure whether this works in humans yet but we are beginning to think it does.

I would like just to show you some pictures of some bone marrow here. This normal bone marrow. It is black because of the blood cells that are being formed there into different rats, two different mice.

This particular mouse got a lethal dose of radiation and 24 hours later it was given spleen from another baby mouse and—I beg your pardon. This one received nothing.

You can see this picture taken at the end of 4 days, most of the cells had disappeared. This animal here received protection from spleen from baby mice and you can see that this is denser, there are more cells here on the fourth day.

Actually, if I were to show you a picture taken on the eighth day after irradiation, this mouse which was protected, the bone marrow would look as dense as that. It has come back that fast. This one, however, that received no protection would still be blank.

TREATMENT FOR RADIATION

Now, to show you what we have been interested in in people, here are a couple of little girls; they are twins, identical twins. This little twin here had leukemia. This was her twin sister. This youngster received 850 roentgen units which certainly would have been a fatal dose of radiation. After the irradiation she was given bone marrow donated by her twin sister.

This picture was taken I think, 2 or 3 months after the procedure. Here her leukemia is quiescent. I do not think anybody pretends it has been cured but the child is feeling well and is happy. The only real difference is that the hair has not all come back yet and of course, loss of hair is a very sensitive indicator of heavy radiation. I thought you would like to see this.

I have just learned that at Harvard now, they have recently transplanted a kidney from one child to another and prior to the transplant the child getting it received 450 roentgens of radiation, by no means a fatal dose. The child required no transfusion of bone marrow and 4 months have gone by and that kidney is in the child and functioning normally.

Now, this I think, is a good background for getting—this gets me into the peaceful use for medicine and agriculture. I have shown how research which was directed toward trying to find out ways of treating radiation injuries has helped to ameliorate a little girl's leukemia.

Here is what we are doing with neutrons from a reactor, such as Dr. Pittman has been talking about, at Brookhaven in the treatment of brain tumors.

Here is the reactor; here is the patient. The patient is injected with a solution of boron (20-mule team borax), and about 20 minutes after injection the head is exposed to the neutrons from the reactor and the neutrons split the boron atom and produce intense radioactivity in the tumor. This is not a proven successful treatment yet, but with the new facility we hope that very shortly this program will move toward and produce some cures.

Now, in passing, I might mention that radioiodine, radiogold, radiocarbon, phosphorus, and hydrogen are all making important contributions in the diagnosis and treatment of such diseases as angina pectoris, abdominal cancer, and the like, or to a more definite understanding of the nature and the cause of the diseases of maturity, hardening of the arteries, Brights disease, and cancer. The latter information will certainly hasten the day when we can prevent or cure these conditions.

AGRICULTURAL USES

In agriculture, Department of Agriculture scientists have eliminated the screw-worm from Curacao and they are apparently very successful in removing the screw-worm from Florida.

In the plant sciences new and improved varieties of rye, peanuts, beans, and peaches have resulted from radiation induced forms of propagation.

Here is the gamma field at Brookhaven with the intense radiocobalt source here and the plants growing in sectors, there are actually peach trees growing around it and receiving radiation. You will be interested to know that just this year a new variety of peanut developed at the University of North Carolina under contract with AEC, a new variety known as NC4X is now available and it is one which has a greater hull strength, fewer damaged kernels and greater resistance to leaf spot disease.

Similarly, we have developed as a result of the activities here at Brookhaven a new variety or two new varieties of freestone peach which fruit at different periods of the year. So, if a person has in his orchard a standard variety he can have fruit borne in his orchard over a period of a month to 6 weeks instead of a couple of weeks and either he sells it or he has to let it rot on the tree. This will be a real advantage in the fruit industry.

Mr. CANNON. Would it be sufficiently economical to be used commercially?

Dr. DUNHAM. It is expected that it will be, yes. There is no expense to it once the varieties are developed. It is made freely available to farmers who wish to use it whether we are talking about peanuts or talking about the new varieties of peaches.

INSTRUMENTS TO DETECT RADIATION

One other aspect before I finish my presentation of our program, is the development of intruments to detect radiation. This is a part of our day-to-day operation and also is a part of our contribution toward civil defense against nuclear war. I believe you are aware that hearings are going on in the Joint Committee right now about the nature and shape of the nuclear war.

Largely, at Dr. Libby's instigation Mr. Johnson here, head of our Radiation Instruments Branch, working through commercial organizations, developed these two instruments which are essentially a very ordinary portable radio which happens to be RCA-Victor and this is a transistorized Emerson job but into which has been incorporated a radiation detection device. You can actually read this one while

the other makes the noise spontaneously as the radioactivity increases in intensity.

(Demonstration.)

Dr. LIBBY. We hope this will be sufficiently inexpensive so that it will be generally available to every one.

In case of war people will have the instrument in their homes which would tell them they are in danger.

Dr. DUNHAM. At the same time they will be in touch.

Mr. JENSEN. Will it register the amount of radioactivity?

Dr. LIBBY. Yes, sir.

Mr. JENSEN. Will that be made a part of a radio?

Dr. LIBBY. A commercial radio, we hope, if we can get it cheap enough. That is our problem, to see whether we can get it made cheap enough. I think we have a pretty good chance of doing it.

Mr. CANNON. Have you concluded, Doctor?

Dr. DUNHAM. Yes, I have, sir.

Mr. CANNON. The committee will go to the floor and vote. We will return immediately.

Dr. Aebersold?

PRODUCTION AND USES OF ISOTOPES

Dr. AEBERSOLD. Gentlemen, it is a real privilege to tell you about the very many beneficial uses now being made of radio isotopes. They are simply radioactive forms of ordinary elements—radioactive forms of elements such as we and our surroundings are composed of.

They represent the most widely used form of atomic energy today. The amounts of energy from radioactive atoms are infinitesimal but the jobs they do are tremendous. Most people, even many of us the Commission, do not fully appreciate how widely used and beneficial isotopes are. I would like to give you some statistics on this.

There are over 5,000 research, medical and industrial groups using radioisotopes throughout the Nation. These cover all the States that you gentlemen represent, and all our territories. They are also used by 70 nations of the world in approximately the same kinds of use as in the United States.

MEDICAL USES

Mr. JENSEN. Will you list those uses?

Dr. AEBERSOLD. Yes, also I will give you some demonstrations. We recently made a study of how many medical research projects in the United States use isotopes. This turned out to be over 2,500 frontline research projects studying every kind of disease—cancer, heart, arteriosclerosis, leukemia, anemia, polio, multiple sclerosis and so on. All 82 medical schools use isotopes and have related teaching programs, many through grants of equipment from the AEC. Practically every medical student in the future will learn how to use radioisotopes.

Two thousand medical groups, most of the VA hospitals and our large hospitals here in town all use them. The number of patients that are diagnosed a year with radioisotopes approaches half a million and a hundred thousand receive treatment.

AGRICULTURE

All the major agricultural experiment stations use them in hundreds of studies on controlling animal and plant diseases, controlling weeds and insects, and on how to improve efficiency of farm production.

In industry there are several thousand plants using isotopes in atomic control devices and research to improve hundreds of consumer products. A large fraction of the products that reach the public today are improved in quality by atomic control devices which use isotopes: 90 percent of the cigarettes, half of the tinplate of the country, and good fraction of the paper, plastic sheet, metal sheet, and so on are all monitored by atomic isotope devices.

The savings in industry alone have been estimated at many millions of dollars per year and, of course, even more important, a greatly increased productivity. Now when all the benefits in all fields are added up, it is fair to say that radioisotopes are the major and most dramatic success story of atomic energy today. I would like to demonstrate to you something about these extremely useful atoms.

DEMONSTRATING USE OF ISOTOPES

First of all here is a Geiger counter and scaler that you are familiar with. With it you can measure all types of atomic particles. Every time you see the light on this panel light or hear a click, it represents one radioactive atom decaying by giving off a ray. You note in the room a little background radiation just from cosmic rays and natural radioactivity in materials around the room.

Here is alpha particle source. Those are alpha particles (helium nuclei) like you get from uranium, plutonium, polonium and so forth. Those heavy alpha particles are now completely stopped by one sheet of paper. This shows you how easily alpha particles can be shielded against.

This is a beta ray source, that is, it gives off high-speed electrons with energies of hundreds of thousands of volts. This represents isotopes like carbon 14, calcium 45, radioactive sulfur, radioactive strontium, radioactive chlorine, and so, on whose only radiation is beta rays.

Observe that one piece of paper won't stop very many beta rays. It does stop some however. Enough are stopped that I can measure the thickness of this paper. Using beta ray sources and a detector one can measure the thickness of paper and other thin material to 1 percent. Also we can do that when the sheet is moving 500 feet a minute as in paper production. So thousands of beta ray thickness gages are being used to measure everything made in sheet form, newspaper, sand paper, adhesive paper, scotch tape, floor covering, linoleum, metal foil, etc.

If I put enough thickness here you see I can also cut out completely these beta rays. So they are stopped by thickness of material of fractions of an inch to as much as say ½-inch. Now, here I have a gamma ray emitter. This is ordinary uranium or radium. Also it represents the radiation from isotopes like cobalt 60 and cesium 137. Note how large a thickness of material that gamma rays penetrate—some sources require many inches of lead or feet of concrete and still all the rays are not stopped. Here is an ordinary radium dial watch.

Now the fast rate of clicking sounds bad. On the other side of the watch it is not quite so bad. So that the side that is in contact with the wrist is not too high in dosage. Still it has been estimated that wearing the watch like this gives a dose to the gonads of a few milliroentgens per year.

Now here we have a bright luminescent source using tritium, radioactive hydrogen. This is an isotope that has very low beta energy only. I wish to show you that *no* radiation comes from this very large bright source but much comes from this radium dial. We could thus replace radium in fluorescent materials by tritium with great safety.

This tritium is widely available now for civilian use for all kinds of luminescent markers. It can be used for watches clocks, emergency exits, signs and so on. The radiation from these is so small that it will not even come through the covering glass.

I have illustrated that radioisotopes can provide three kinds of rays, alpha, beta and gamma with different properties and that they can all be useful in various ways.

People ask me what does an isotope look like. The radioisotope of an element looks exactly the same as the nonactive element. These are dummy samples not radioactive. This radioiodine is the same kind of iodine that you paint on your skin. The only difference is that it has more neutrons in the nucleus (I^{131}) so this is radioactive but it behaves exactly like iodine. For diagnostic tests you give a patient a drink of this; as a matter of fact, they now put it up in capsules. These are radioiodine capsules. The capsule is swallowed. Twenty-four hours later you measure the amount of radioactive iodine taken up in the patient's neck by a Geiger counter over the thyroid.

You can tell how active the thyroid gland is. That is what we call a tracer use. Tracer uses are most extensively used for research in all fields. Here are dummy samples also of radiophosphorus and cobalt. I will tell you how we make this cobalt radioactive. This is ordinary cobalt; you put that in the reactor, bombard it with neutrons in the reactor. Neutrons have no trouble going into the nucleus. They have no charge so slip right in. This is cobalt 59. When we bombard this, part of the atoms change to cobalt 60. We only have to change 1 percent of these atoms to cobalt 60 until it is more active than radium.

We can do more than that. We make these things a hundred times more active than radium. This equals 100 grams of radium in its activity. It is used for treatment of cancer. It is equivalent to several pounds of radium which would cost about $20 million, at the present price of radium, whereas this radiocobalt only costs a few thousand dollars. What it means is that you cannot do this job with radium.

TRACERS

Now that illustrated using large amounts. We can also use cobalt in small amounts as a tracer. Cobalt is a part of vitamin B–12; vitamin B–12 is used in the process of making blood. A very tiny amount—millions upon millions of times smaller than the amount used for treatment can be used in tracing this vitamin—where it goes through the animal, plants, or human system and what happens to it.

So we have very, very tiny amounts used for tracer experiments and on the other hand billions of times larger amounts used for treatment.

IMPLANTS

In addition to treating outside the body with a beam of radiation we have implants of either radioactive gold or radioactive cobalt which can be sewn directly into cancers that can't be removed. The surgeon sews radioactive sutures like these right into place in the cancer to destroy it with radiation.

Later, he can pull the sutures out without opening the patient again and remove these sources from the body when the treatment is over.

POWER OF TRACERS

Now, I would like to give you some idea of the power of tracers. As you can see with this Geiger counter we can detect individual atomic events. This means that we can take 1 ounce of radioactive sugar and put in 2 billion 100-pound sacks of sugar, mix it uniformly and take out a spoonful and with one of Dr. Libby's low level counting devices you can measure the activity in a single spoonful. That is a dilution of a trillion.

In addition to great sensitivity, we have exact specificity. We can take a batch of atoms and follow them in a complicated animal like a cow, independent of billions of other atoms and hundreds of other chemical processes. Also you can study many of these processes in the living animal or person.

We now have ways of using radioactivity for tracing thousands of different things, nearly all the elements and their compounds. We can make radioactive forms of materials common to the body or any type of system we want to study. For example, we can make radioactive sugar, starch, vitamins and hormones, to study what these things do in plants, animals, and human beings.

STUDIES WITH INDUSTRIAL MATERIALS

Also, we are now doing studies with industrial materials. I have listed here piston rings because piston rings are made radioactive to study wear and to test one lubricant compared with another. You can study the wear of tires at different speeds. Also one can make radioactive organisms such as blood cells to study the lengths of their life in blood. The length of life is different, for example, in patients with leukemia.

Polio and other viruses have been made radioactive for tracer studies. Several hundred varieties of drugs have been made radioactive; also all the antibiotics and various types of bacterial agents to see how these drugs are used in a human. We have made radioactive bacteria and even radioactive mosquitoes for tracing the migration habits of mosquitoes for carrying of disease.

This gives us the power to trace what all kinds of things are doing in the human body—plants, animals, and industrial systems. The same type of things are done in agriculture as are done in human beings.

STUDIES IN AGRICULTURE

You study metabolism of plants, particularly the trace elements—elements like cobalt, nickel, zinc, copper, and so forth, are in plants in tiny amounts and you cannot very well detect them by other means.

As you see, the uptake of fertilizer has been studied extensively. That will help us learn how to use fertilizers more effectively. We can study animal disease and the nutrition of animals and how to get better milk, egg, and meat production.

In industry we have a lot of different uses. I said we can do tracer work. Also, we have the tracer listed at the bottom here, studying friction and diffusion, the action of detergents, soaps, preservatives, catalytic reactions. But in addition, we can use larger sources more in industry for things like measuring the thickness of materials I have shown here; also very large sources of cobalt can be used to take pictures of very thick castings and welds.

A modern ship made by the Navy may have 10,000 welds. With a portable source containing a little piece of cobalt that will be equal to about 10 or 15 grams of radium, pictures can be rapidly taken of welds or castings to insure quality and safety.

My time is nearly up. I would like to leave time for those to follow.

USES IN BASIC SCIENCE

I would, however, like to indicate that the isotopes are used in basic science of all kinds. One important thing that was done is the study of the process of photosynthesis with radioactive carbon. We gained information on how a plant can take simple one-carbon carbon dioxide, and turn it into complicated six-carbon sugars inside of 60 seconds. The speed is so great you cannot follow it by any other method. Also tracers permitted finding the intermediate process along the line. This is the process by which all life exists, the process of capturing sunlight and turning it into energy for food.

USES OF HIGH INTENSITIES OF RADIATION

I would like to close by saying a few words about uses of very high intensities of radiation which I did not cover. With reactors we can now make millions of curies of radioactivity. These amounts I have shown are microcuries. I am now talking about levels of radioactivity that are many billions of times greater.

Here I have dummy samples of some useful fission products, the products that store up in the fuel rods of reactors. They are called the ashes of the atomic furnace.

Let me give you one example. You all heard of strontium 90, how dangerous it is. Actually, in this loose powder form it might be. It might get loose, and it could be serious. This is 1,000 curies of strontium 90—a dummy sample. That would supply a body burden for several million people. If it were distributed evenly among them, it would be a maximum internal permissible dose.

However, in these kinds of atomic batteries you saw demonstrated here, this is the safe form in which we plan to put that strontium. This is strontium oxide and titanate fired at several thousand degrees. It now becomes a fused brick.

That strontium brick can be boiled in light acid, and you get practically no activity at all from it. You then seal it up in double stainless steel. This becomes a heating element heated by radioactivity. The heat will supply only a few watts.

The radiation is only beta rays and thus easily shielded. You get very little or no penetrating radiation like you do from gamma rays. You then put thermoelectric junctions along here and you take electricity off. You then have a remote source of power without any moving parts.

This can be used in remote weather stations for sending weather data down from all over the Arctic. It can be used underwater for monitoring against submarines. It can be used in satellites for monitoring for rockets or taking data on outer space.

So these fission productions are going to be extremely useful. Here is another one—cesium 137. This is also made in a fused brick so it is very safe. This puts out gamma rays equivalent to a million volt X-ray machine. This amount will last 30 years before half of its activity is gone. For 30 years it can treat cancer patients, day and night—a very effective source for cancer treatment. That represents about 1,500 curies of cesium 137.

Mr. CANNON. Thank you, Doctor.

CURE OF CANCER

Mr. JENSEN. Who wants to comment on the success we have had in the cure of cancer? When do you expect to be able to prove conclusively that you can cure cancer with isotope treatment?

Dr. DUNHAM. I do not think one can make sweeping statements about cancer. Many times people have stated that 10 years from now we will have the answer. I don't think there will be a single answer, Mr. Jensen. On the other hand, a number of cases, I don't know exactly how many, of cancer of the thyroid gland have been essentially cured with radioiodine, something which could not have happened before.

The use of cobalt 60 for the treatment of cancer is very similar to that from 2- or 3-million-volt X-ray and, as you know, they have cured selected cases of cancer.

Mr. JENSEN. In the early stages?

Dr. DUNHAM. Yes; or even some later stages have been destroyed. Recently—and I think some of your committee visited the large accelerator at Berkeley—they have taken patients who were hopelessly riddled with cancer, breast cancer, and destroyed the pituitary gland with the beam of the large cyclotron. John Lawrence tells me that several of them now, after 3 years have no evidence of active growth of the cancer. So that progress is being made, but I would certainly not want to say when one has the final answer to cancer, because whatever I say I am sure I will be proven wrong.

Mr. JENSEN. Can it be said and proven that there has been up to this time cancerous conditions cured in the early stages of cancer by radioactive isotopes?

Dr. DUNHAM. Yes. In a similar way with skin cancer, Dr. Low-Beer did this some years ago in Berkeley with radio phosphorus. He dipped a piece of blotting paper in radio phosphorus, put it on the

skin cancer for a few hours, threw it away, and the skin cancer was cured.

Mr. CANNON. The medical profession has never announced authoritatively or officially that they are able to cure cancer?

Dr. DUNHAM. I think, Mr. Chairman, that the medical profession will state categorically that many cancers have been cured, but that there is a cure for cancer in the sense that all cancers can be cured or even most cancers can be cured—this has not happened yet.

Mr. CANNON. Mr. Fogarty?

Mr. FOGARTY. Doctor, is it a fair statement to say that because of some of this research that life has been extended in some patients that was not possible 4 or 5 years ago?

Dr. DUNHAM. Very definitely. I think the statistics of the Cancer Society show that.

Mr. FOGARTY. Is it a fair statement that the longer you can keep a person living, the better the chances are that you might make further progress in that area?

Dr. DUNHAM. Not only that, you might find a special answer to his case. I always think of the case of Dr. George Minot, who was later one of the codiscoverers of liver as treatment for pernicious anemia. He was dying of diabetes when insulin was discovered. Fortunately, he was one of the first people for whom insulin was made available in this country by Dr. Banting.

Mr. FOGARTY. Dr. Aebersold talked about the use of isotopes and that the cells of humans with cancer are much weaker. Is there any possibility of that turning out to be a sort of diagnostic tool of discovering whether a person has cancer or not?

Dr. AEBERSOLD. I think the greatest value of isotopes is in getting knowledge about cancers through radioisotope tracers. You can study the metabolism, the detailed biochemical processes, of cancer cells and compare this with cells not cancerous. Cancerous cells appear to do everything that a normal cell does. They do everything qualitatively the same as far as we can tell—they use sugars, vitamins, hormones, amino acids, and so forth, but they do so at different rates.

We have not yet found, so far as I know, a specific difference in biochemical processes between cancer and normal cells and we have studied thousands of isotope-labeled compounds in these cells. We do find differences in rates of processes. One thing that can be done with radiotracers is to check one drug treatment against another. One way to check a new anticancer drug is to use it on laboratory cultures of the cancer cells, then use a radioisotope compound that is going to be built into the cancer cells, for example, into their fast dividing nuclei, and see if you can block this process with the particular drug.

You can see whether the drug actually blocks the uptake of essential nutrients in various types of cancer. In that way you can find more effective and specific drugs for each type of cancer, i.e., find specific molecular arrangements that are most effective for blocking cancer cell metabolism.

There appears to be something in some cancer patients that amounts to a change in his whole immunity or defense against cancer. Most people have an immunity against cancer. Some people seem to lose that immunity and get cancer that continues to spread. You can

do everything for them, surgery, radiation, etc., and the cancer goes right on. In other people you take out some of the cancer and apparently they have enough remaining immunity against cancer to overcome any remaining disease or tendency to reoccur.

So it is a growing impression that cancer is a systemic, perhaps a metabolic, disease. One proof is that the red cells in a cancer patient do not live so long. We can put tracer activity in red cells to follow their life span. Normal red cells last about 140 days, but those in a cancer patient may last about 50 days or less.

Mr. FOGARTY. Is that a fairly well documented fact?

Mr. AEBERSOLD. Yes; but it is not a diagnostic test because you already know that the person has cancer. It is, however, an opinion of Dr. Libby and others that someday you can get tracers to find incipient states of disease. You will find out by tracing details of body chemistry that they are going to get a disease before they get it, before it becomes grossly manifest.

Mr. FOGARTY. That is one of the most important problems right now, because there are so many forms of cancer that can be cured by surgery or drugs if you knew it at the time.

Dr. AEBERSOLD. That is right.

Mr. JENSEN. By this tracer you discover where the cancer growth is located in the body, and then your next problem is you learn how to attack that cancer in order to stop the cancerous growth, and that is the thing you are searching for all the time.

Dr. LIBBY. That is right.

Mr. CHAIRMAN. Can you say that you know the cause or cure of cancer?

Dr. LIBBY. I don't believe they can say that. Do you think we could, Doctor?

Dr. DUNHAM. No, sir; we cannot make that categorical statement.

Mr. FOGARTY. Dr. Dunham, on those two pairs of twins that you did show us, I assume where you said this child had leukemia—did she have acute leukemia?

Dr. DUNHAM. Yes.

Mr. FOGARTY. Is it not a fact that 10 years ago if you had a child and diagnosed acute leukemia, the child only lived a matter of a few weeks?

Dr. DUNHAM. This child should be dead now in the ordinary course of events.

Mr. FOGARTY. This child is living and you still do not say you know the cause or you do not know the cure, but the facts are that because of what you have done that child is still living.

Dr. DUNHAM. Certainly.

Mr. FOGARTY. Which was not possible 10 years ago.

Dr. DUNHAM. That's right.

Mr. FOGARTY. So even though we don't know the cause or cure life is being extended and somebody is being given an extension and in some cases, apparently, it has been cured.

Dr. DUNHAM. The same is true of diabetes. We treat it very well and people live long times but we don't know what causes it and we don't cure the underlying defect but we can treat it.

Aspects of Obtaining Uranium

Mr. Cannon. Dr. Johnson, something on obtaining uranium?

Mr. Johnson. Mr. Chairman, I will briefly outline some of the aspects of obtaining uranium.

Uranium is the basic material for nuclear energy programs which does not ocur in nature as a metal but in various chemical compounds which constitute the various uranium minerals.

Many of these minerals are brightly colored—orange, green, red, and yellow, while others are drab, almost indistinguishable from sandstone and other enclosing rocks. Pitchblende, the richest uranium mineral, has the appearance of a black, pitch-like substance.

After removal from the earth, the first step in the production chain is the processing of the ore into a more concentrated form. The uranium ore is crushed and ground to a fine powder, and then digested in an acid or alkaline solution in the form of a high-grade concentrate.

Most ores processed today have a uranium content ranging from one-fourth of a pound to eight pounds of U^{308} per ton and the mill concentrate derived from such ores generally contains from 1,200 to 1,600 pounds U^{308} per ton.

It requires from 400 to 500 tons of average grade domestic ore to produce 1 ton of U^{308} in concentrate. Because of the lower grade, approximately 1,000 tons of average Canadian ore are required for 1 ton of concentrate.

CONTENT OF ORES

In South Africa, from 2,000 to 8,000 tons of gold tailings are chemically processed for each tone of U^{308} produced in a concentrate. Earlier in our atomic energy programs, it looked as if the low-grade domestic shales would have to be utilized to supply part of the military requirements. This would have meant mining and chemically processing 20,000 to 30,000 tons of shale for each ton of U^{308} recovered in a concentrate. Preliminary work indicated a cost of from $40 to $60 a pound of U^{308}.

When the Atomic Energy Commission was established in 1947 there was no domestic uranium production. More than 90 percent of our uranium was coming from the Shinkolobwe mine in the Belgian Congo, in the center of Africa. The product of this mine was shipped 1,400 miles by rail and river to the coast and then 7,000 miles across the Atlantic to our eastern ports.

The only other supplier at that time was the Port Radium mine near the Arctic Circle in Canada. The uranium from this mine moved 1,200 miles by lake and river to railhead. Nine months of the year this water route was closed by ice.

The only known deposits in the United States were the uranium-vanadium ores of the Colorado Plateau. In 1948, partially developed ore reserves were estimated at about 1 million tons containing 2,500 tons of recoverable uranium. This is equivalent to less than 2 months present domestic production and less than 1 month's requirement for the current Commission program.

During this earlier period every expansion of the atomic weapons program was contingent upon being able to increase the uranium

supply. Even the limited supply we had then depended upon keeping open the long, vulnerable shipping routes.

A plan for shipping the uranium from Shinkolobwe by military air transport was in readiness in case of emergency. Yet, even this mine had only limited assured ore reserves and we could never count on a production rate more than a few years in advance.

DEVELOPING NEW SOURCES

Probably no program so vital to the defense of this country ever depended upon such an uncertain supply of basic material. This was a matter of serious concern to the Joint Committee and to the Commission. New sources of uranium had to be found and brought into production—preferably on the North American Continent.

This was the reason for establishing programs, in this country and in Canada, to encourage and support an intensive search for uranium deposits. There was little geological evidence or historical background upon which to predict the results of such a search. Prior to nuclear fission there had been little interest in uranium and few commercial deposits had been found and developed.

Uranium had been mined primarily as a source of radium. Shinkolobwe could supply this market by part-time operations. Later, the Port Radium mine shared a portion of the market. Both mines had vein-type deposits and contained pitchblende ore. It was generally thought that the discovery of deposits of this type would be necessary if we were to develop substantial production.

The uranium-vanadium ores which had been found on the Colorado Plateau were in the form of disconnected lenses scattered through certain sandstone beds. The history of the area, which covered about 40 years of intermittent mining, indicated that most of the ore bodies were small, ranging from a few hundred to a few thousand tons, with occasional deposits of a few hundred thousand tons.

The deposits that outcropped could be found by surface prospecting, but most of the unprospected areas would have to be explored by drilling. There were practically no guides to indicate just where to drill. Blind drilling of any considerable part of such a vast area would be extremely expensive. The targets were small and could easily be missed even in drilling an area in which deposits occurred.

The only chance for a substantial measure of success was to encourage extensive surface and subsurface prospecting; to develop better geological information on uranium occurrences; and to improve the methods and equipment used in the exploration for uranium. These were the essential elements in our domestic uranium program.

ORE RESERVES

Progress was slow for a number of years. After 5 years, at the beginning of 1953, domestic ore reserves were only 3 million tons containing 6,000 tons of U^{308}. At the beginning of 1955, 7 years after the domestic program was established, ore reserves were approximately 10 million tons, less than 2 years supply at today's mining rate.

Ore reserves now are in excess of 80 million tons and mining is at a rate of more than 7 million tons a year. Nearly 70 percent of these reserves were developed during the past 3 years. Much of this ore is in the form of multimillion-ton ore bodies.

IMPROVED METHODS OF DETECTION

Most of these large deposits did not outcrop, or had relatively inconspicuous surface exposures. Geological knowledge and improved exploration methods, developed since the initiation of our program, were important factors in the discovery and development of these hidden deposits.

The Geiger counter, first used as a prospecting tool in the war period, and the scintillometer, were perfected and their uses extended to include drill hole probing and airborne radiometric surveys. Nearly every prospector, and many of the thousands of "week-end" prospectors, carried Geiger counters.

Drill hole probes and airborne radiometric equipment also proved to be of major importance. The AEC and its contractors, particularly the U.S. Geological Survey, made important contributions to the development of the geological knowledge and the improved exploration methods and equipment.

PROCESS DEVELOPMENT

The AEC process development programs also played an important role in developing our uranium production. They have been responsible for the development and introduction of most of the basic processes now used in the mills for recovering uranium from ore. In the past 10 years, average uranium recovery has increased from about 70 percent to more than 90 percent, milling costs have been reduced, and concentrate prices have been lowered.

As domestic resources developed, an increasing percentage of our uranium has been supplied by the mines of this country. From the beginning of the atomic energy program in 1942 to July 1, 1955, 83 percent of the total uranium purchased by the United States came from foreign sources, mostly overseas. In fiscal year 1960, domestic producers will supply 49 percent of our purchases, Canadian 38 percent, and overseas 13 percent. After 1962 we may be getting 80 percent or more of our uranium from domestic mines.

In a little more than 10 years, starting with practically no production, an insignificant reserve of commercial-grade ore, and uncertain prospects, the United States has become the largest uranium producer in the free world.

Mr. CANNON. The price of uranium has declined drastically in the last few years. How do you account for that decline?

Mr. JOHNSON. The decline in the price of uranium has been due to the new processes which were developed by Commission contractors and the construction of larger mills because of the larger supply of ore. When we started our program in 1948, a 100-ton-a-day mill or a 200-ton-a-day mill, that is the rate of ore treatment, was the largest that could be supported by the ore reserves in any local area.

Today we have some mills treating up to 3,000 tons of ore a day and a number of mills processing from the 1,000 to 1,500 tons per day. The mill recovery from 1948 through 1953 ranged from 70 to 80 percent. This has gradually improved and now the average recovery of all our mills is about 90 percent.

Recovery is an important factor in the cost of production. The average grade of ore milled has remained almost constant from the

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first days of our production in 1948—approximately 5 pounds of uranium oxide per ton of ore. Although there has been little change in the average grade of ore, ore from individual deposits range from about 3 pounds to 8 or 9 pounds per ton.

Mr. CANNON. You have no apprehension as to any dearth of source material, in the near future?

Mr. JOHNSON. Not in the near future and I believe—this is a cmatter of opinion supported by considerable geological information—that with proper planning and reasonable leadtime, this country could probably maintain its position as one of the world's leading uranium producers.

We believe on the basis of geological information developed during the past 4 or 5 years, that there remain large areas in the United States favorable for uranium occurrence and that the undiscovered reserves are probably many times that of the ore reserves we now have developed.

Of course, this is a matter of conjecture, a matter of judgment. Most of the deposits that will be found in the future, as in the case of the large deposits that have been found during the last few years, will be buried deposits which will be found by drilling on the basis of geological evidence.

Mr. JENSEN. I want to ask a question, Mr. Chairman.

What was the amount of uranium used in fiscal 1958?

Mr. JOHNSON. I believe the figure was approximately 26,000 tons.

Mr. MAGNUSON. Is this ore?

Mr. JOHNSON. No, the concentrate, uranium oxide.

VOLUME OF URANIUM PRODUCTION

Mr. JENSEN. What was the amount produced in that fiscal year?

Mr. JOHNSON. The amount that was produced?

Mr. JENSEN. Produced.

Mr. JOHNSON. Throughout the world?

Mr. JENSEN. No. Here in the United States and in the free world.

Mr. JOHNSON. Fiscal 1958?

Mr. JENSEN. Yes.

Mr. JOHNSON. In fiscal 1958 the United States produced 10,240 tons; Canada, 9,475; and our share of the oversea production was about 6,600.

Mr. JENSEN. We produced approximately 1,000 tons more than we actually used?

Mr. JOHNSON. No; we used all that we produced.

Mr. JENSEN. You actually used all you produced?

Mr. JOHNSON. Yes. The Commission at no time has had a stockpile of uranium oxide, only the material that is in transit and in the pipeline.

Mr. JENSEN. You have no stockpile of uranium concentrate right now?

Mr. JOHNSON. No.

Mr. JENSEN. You just live from hand to mouth?

Dr. LIBBY. We have a fairly big pipeline, of course.

Mr. JOHNSON. The material that comes from the United States and foreign suppliers moves directly to the refineries and into the production of fissionable materials.

Mr. JENSEN. If we had greater production, could we use that greater production beneficially, profitably?

Mr. JOHNSON. I believe so. I think Mr. Bloch of the Production Division, or the general manager may wish to speak to that.

General LUEDECKE. Our production of the output from the production plant which Mr. Bloch will cover in a minute, are programed against requirement and for some years ahead of us there are established needs against which that production would be applied as of any particular time.

Mr. JENSEN. But you do have a stockpile of uranium ore, do you not? Is there a stockpile, owned by private concerns, of uranium and ore?

General LUEDECKE. In the sense of ore reserves only, sir. We are not taking it out of the ground, stacking it up prior to processing.

Mr. JOHNSON. Each of the mills maintains a stockpile of ore for continuity of operation and for blending the ores. The Commission, during the period when new mills were being constructed supported production by acquiring a considerable stockpile of ore. At one time AEC ore-stockpiles were in excess of a million and a half tons; they now are about 750,000 tons.

Mr. JENSEN. Do these industries have the ability to produce more uranium ore, that is mine it, stockpile it, than they are now doing? Do they have capacity in case we need to furnish more ore to be processed into uranium concentrate?

Mr. JOHNSON. Our mining industry as now established and the milling industry are in a position to produce a substantially greater quantity than the Commission is purchasing under its present contracts. In case of need we could expand production by a significant amount with existing facilities; with relatively short lead time we could expand domestic production substantially.

Mr. JENSEN. That is all.

Mr. FENTON. Is it a secret as to where our main bodies of ore lie?

Mr. JOHNSON. No, no secret.

Mr. FENTON. You mentioned shale a minute ago. Is the Colorado oilfield shale used?

Mr. JOHNSON. The oil shale deposits of Colorado do not contain uranium in any significant amount. The black shales that were once considered as a possible source of uranium are in the Tennessee-Kentucky area. There are also vast deposits of shale of this type in the Baltic area, Sweden and Russia. Throughout the world there are great supplies of very low-grade material from which uranium could be recovered, but at great expense.

Mr. CANNON. May I ask the representatives of the Department here, has anything been said this afternoon which you think might be left off the record?

General LUEDECKE. Up to this point I think not, sir.

Mr. CANNON. You think that there is nothing you have given us this afternoon that cannot be put in the record?

General LUEDECKE. I think this is correct, sir. If we might just review it to make sure there is not some small statement. That will not be true of the next statement.

Mr. CANNON. Director Bloch, Division of Production, on producing special nuclear materials. This is the last paper. This will close our program for this afternoon.

Mr. Bloch?

Production Plants for Special Nuclear Materials

Mr. Bloch. Mr. Chairman, I would like to just discuss briefly the complex of production plants which are required to produce the special nuclear materials that are used primarily for weapons, U^{235} and plutonium, and also other special materials that are used in weapons which General Starbird mentioned the other day.

Mr. Cannon. I note your chart is marked "Secret." You have no objection to the statement you are about to make being published in the hearings?

Mr. Bloch. Sir, most of what I will have to say is classified and could not be published; part of it can. We will have to review the transcript to delete the classified information.

Mr. Cannon. When the transcript of your remarks comes to you gentlemen, if there is anything you think should be omitted, just bluepencil it.

Mr. Bloch. Well, our operation starts with the receipt of the uranium concentrates which are procured by Mr. Johnson. The first step is to purify and refine these uranium concentrates into highly purified materials.

PURIFICATION PROCESS

Mr. Johnson indicated that he got a concentrate which was 60 to 80 percent U^{308}. We have to purify that into highly purified uranium or highly purified uranium salts. This is done in several plants, one in Ohio, one at Weldon Springs, Mo., and a plant in southern Illinois.

The processes used are essentially conventional chemical processes except the requirements for purity are quite high. The samples which you have there represent various intermediate products. The orange powder is the product from the refinery. The brown powder is an intermediate product and the green powder is what we call green salt.

The green salt is the place where our refining process splits. The green salt is reduced with heat to metallic uranium and there is a sample of metallic uranium. The metallic uranium is cast, rolled, and machined into fuel elements for our production reactors.

In the other part of the chain, the green salt is subjected to heat and fluorine, and produces a colorless gas called uranium hexafluoride. This gas becomes the feed to our gaseous diffusion plant. In passing, I have a photograph of one of our feed processing plants. This is the one at Weldon Springs and it consists of a sampling facility, refinery, what we call the green salt plant, metal plant and then shops, warehouses, service buildings, and other related facilities.

Incidentally, that piece of uranium metal, it took about 2,100 pounds of ore mined from the ground to produce that 3½ pounds of uranium metal.

Our next major operation is the production of enriched uranium 235. As you recall, normal or natural uranium contains about one part of the U^{235} isotope to 140 parts of the U^{238} isotope.

Mr. Jensen. Why can't England produce enriched uranium?

I got their explanation over there. What about yours?

PRODUCTION OF ENRICHED URANIUM

Mr. BLOCH. I am about to discuss how we produce enriched uranium. It is produced in the gaseous diffusion plants. There are three plants, one near Portsmouth, Ohio, another in Oak Ridge, Tenn., and a third one at Paducah, Ky.

The normal uranium is converted to the form of a gas and that gas is enriched through a number of what we call converters and this schematicaly shows what happens. The gas is pumped through one of these converters. The lighter U^{235} isotopes travel a little bit faster than the U^{238}. So you pump this through a barrier and slightly more of the U^{235} will permeate through the barrier than U^{238}. Then the gas that does not go through is recycled back to the lower stage.

The lighter gas that does go through goes on up. Now, the amount of enrichment you get at any particular stage is very small. So you have to repeat this process several thousand times before you get highly enriched U^{235}. The heart of the process is in this barrier here.

Now, this schematically just shows a big tube, but actually it is performed in a tank, what we call a converter, and I have here a photograph that shows an array of tanks. This is the compressor to pump the gas. These round tanks here are what we call the converters. The gas is pumped through tubes which are inside this tank.

Any one of these tanks can contain a variable number of the barrier tubes which I have just passed around there. The heart of the process is in the barrier tube, its efficiency and the method of manufacture.

Actually, the barrier material and its method of manufacture is one of our most closely guarded secrets.

Mr. JENSEN. Is plutonium a substitute for enriched uranium or vice versa?

Mr. BLOCH. Enriched uranium is used in weapons and also can be used as enriched fuel in reactors to produce power. Plutonium is used in weapons.

Mr. JENSEN. In weapons only?

Mr. BLOCH. In weapons only, although we have a program to develop the ability to also use plutonium in a reactor to produce power, but this is a long-range program.

Here are photographs of the Portsmouth plant. All of the equipment is housed in these huge buildings and it is pretty hard to give an indication of size just from the photograph but there are about 80 acres under roof among those three buildings.

Here is the plant at Oak Ridge, Tenn. Here, here, back here, and the original plant built during the war back here [indicating]. The total roofs there are slightly over 60 acres.

One of the principal requirements for this process of enriching U^{235} is the need for electric power. We have many thousands of stages and you have to pump the gas through these thousands of stages. So we use for the three plants about 50 billion kilowatt hours of electric power a year, which is about equivalent to the amount of power that I understand the State of Ohio uses.

Mr. TABER. Uranium and the other gas is heavier than air all the way through?

Mr. BLOCH. Actually, the pressure is subatmospheric throughout the cascade.

PLUTONIUM PRODUCTION

The next operation is the production of plutonium. I think the principle of the chain reaction has been described previously. This is a photograph of a typical Hanford reactor for plutonium production. This is the reactor building. This is the water tower.

Way down here on the river is the river pumphouse. This is a building that houses the pumps that pump the water to the reactor, to cool the reactor.

Mr. TABER. Where is this?

Mr. BLOCH. This is at Hanford, Wash., sir. I have here a cutaway that shows what a typical Hanford reactor is like. This is the graphite block which serves as the moderator. That is surrounded by about 5 feet of concrete shielding to protect against radioactivity. These rods here coming from the side are the control rods that control the power level.

The fuel tubes and cooling tubes—there are many tubes that go horizontally through the reactor. These tubes are loaded with uranium fuel elements and cooling water is then pumped through the tube and surrounds the fuel element and removes the heat.

There are samples of two types of fuel elements. You will notice they are canned in aluminum to protect against corrosion.

After irradiation in the reactor the fuel is discharged, in the case of Hanford, just by pushing it on through the reactor. These elements are pushed down into water and are stored for a period of about 3 months until the shortlife radioactivity has decayed.

Mr. JENSEN. You put the Hanford reactor in the square building that was one of the first reactors that was built and since then you have been putting these reactors in spherical buildings?

Mr. BLOCH. As far as production reactors go, we have these two types. One is the graphite moderated reactor at Hanford. Three of those were built at Hanford during the war Since the war five more have been built for a total of eight. They are all big blocks of graphite, even the latest ones.

The graphite is the moderator and also the structural material that holds the fuel tubes. In a production reactor the problem is a little bit different than in a power reactor. You want to get your uranium in so as to make your plutonium, so you make them big.

Mr. JENSEN. I get it now.

CHEMICAL SEPARATION

Mr. BLOCH. This is a chemical separation plant. The highly radioactive fuel elements are processed through a plant which is completely remotely operated and again is shielded, the walls and shielding in this plant are 5 to 7 feet thick, made of concrete.

The radioactive uranium is dissolved and goes through a series of chemical extraction and purification steps and there are three streams that come out of the plant. One is plutonium, which is the product. The other is the uranium. This uranium is only slightly depleted by being burned in the reactor, and therefore, it is recovered and recycled. It still has enough U^{235} in it to be very good feed for the gaseous diffusion plants, so uranium is recovered and fed back into the gaseous diffusion plants.

The third stream has fission products which are highly radiocative and which are stored in underground tanks.

I have here a picture of a Savannah River reactor which is a different type. Basically, the Savannah River reactor is moderated and cooled with heavy water whereas the Hanford reactor was moderated with graphite and cooled with light water.

Again, the reactor itself looks a lot different. This is a cutaway. Essentially, it is a big tank about 15 feet in diameter. Here the fuel elements and control rods all come in through the top of the reactor. It is loaded and unloaded by lowering and raising from the top of the reactor.

This tank is filled with heavy water which moderates the neutrons and also cools the fuel. The heavy water goes through heat exchangers where the heat is removed by river water which flows on the other side of the heat exchanger and is recirculated through the reactor.

Mr. JENSEN. What heavy ingredient does heavy water contain that ordinary water does not contain?

Mr. BLOCH. It contains a heavy isotope of hydrogen. Ordinary water is hydrogen with the weight of 1. This is heavy hydrogen which has an atomic weight of 2. Basically it contains a porton and a neutron; whereas, oridinary hydrogen just contains a proton. This is a cutaway again and this is surrounded by 5 or 6 feet of concrete shielding.

(Discussion off the record.)

In summary, this complex to produce the special nuclear material and other weapon materials represents an investment of something over $5 billion and requires about 31,000 people to run. Our production has increased significantly over the years. This has been due to adding new plants, to development work which has enabled us to get considerably more out of existing plants than had been planned, and also to the increased availability of uranium from Mr. Johnson's program.

Mr. CANNON. How do you account for the progress?

Mr. BLOCH. The progress, sir, is due to additional plants. It is also due to the carrying on of a development program which enabled us to get a lot more capability out of the plants we built than had originally been anticipated.

Mr. CANNON. Thank you.

Mr. Luedecke, I would like to ask you one more question off the record.

(Discussion off the record.)

Mr. CANNON. Thank you gentlemen. The committee stands adjourned until 2 o'clock tomorrow afternoon.

TUESDAY, JUNE 23, 1959.

Mr. CANNON. The committee will be in order.

BUDGET STATEMENT BY CHAIRMAN JOHN A. MCCONE

Mr. Commissioner, may we have a statement from you on your budget?

Mr. MCCONE. Mr. Chairman, I have a statement that I would like to read.

Mr. CANNON. We shall be glad to hear it at this time.

Mr. McCone. Mr. Chairman, the Commission appreciates the opportunity we have had of presenting to your committee a general technical discussion on atomic energy. I hope you have found it useful.

Since my appointment to the Commission last July, I have been deeply involved in each step of the budget formulation which has resulted in the estimates now before you. I believe these amounts are required to carry out the program we will discuss with you.

Before proceeding further, let me point out that some of my remarks on military matters will contain classified information. These classified remarks are not included in the mimeographed statement which has been provided to the committee. Therefore, I shall depart from the mimeographed text from time to time in the statement I am reading.

1960 ESTIMATES

As you know, funds for the atomic energy program are provided to the Commission in two appropriations—one covering the operation expenses and one providing for plant acquisition and construction. Our budget under the operating expenses appropriation provides for estimated obligations of $2,550,400,000 during fiscal year 1960. Our budget under the plant acquisition and construction appropriation provides for a 1960 construction program of $293,505,000.

Our estimates for 1960, Mr. Chairman, closely resemble those of recent years. Activities related to military requirements constitute the major portion of the total budget. These activities include the development work on reactors for Army, Navy, and Air Force, the use of the bulk of the uranium and other source materials procured, the production of special nuclear materials, and the development and manufacture of nuclear weapons.

RAW MATERIALS

Turning now to the principal programs of the Commission, I shall discuss first the raw materials program.

Past efforts to obtain adequate supplies of uranium have been very successful. From our own mines and the mines of certain other nations friendly to us, primarily Canada and South Africa, we have ample supplies for foreseeable needs. As a matter of fact, we have taken several steps during the past year to keep the supply as nearly as possible in balance with requirements. We have, for example, closed out our domestic uranium purchase offer, insofar as new uranium discoveries are concerned. Nevertheless, due to outstanding commitments, we will be receiving uranium during the next 3 years at a rate in excess of our yearly requirements.

Thereafter, commitments are below our anticipated requirements.

Projected receipts of U_3O_8 in 1960 total 35,915 tons: 49 percent from domestic suppliers, 38 percent from Canada, and 13 percent from other foreign sources overseas, namely, South Africa, Belgian Congo, Portugal, and Australia.

Total 1960 costs for the raw materials program show an increase of about 5 percent over 1959. Costs are expected to decline somewhat in 1961 and to be substantially lower thereafter.

SPECIAL NUCLEAR MATERIALS

Next in our budget presentation is the special nuclear materials program. The processing of uranium concentrates and other raw materials into special nuclear materials by our complex of large production plants has become a relatively stabilized operation. Emphasis is being placed on process improvements, safety, increased efficiency of operation and reduction of production costs—production achieved through increase in operating power levels of the Hanford and Savannah River reactors and in added uranium 235 production by the gaseous diffusion plants made possible by the cascade improvement program.

NEW PRODUCTION REACTOR AT HANFORD

To meet increased requirements for plutonium we have awarded contracts for designing and building the new production reactor at Hanford, the one major item of plant construction in our entire production program. You will recall that authorization of this large production reactor last year for plutonium production provided for incorporation of those features necessary to permit conversion of the reactor to the production of electricity if this use is indicated at some future date.

In addition to our major requirements to produce plutonium and uranium 235, a smaller but significant production effort is devoted to other materials needed for neculear weapons.

(Discussion off the record.)

Mr. CANNON. You may proceed.

WEAPONS PROGRAM

Mr. MCCONE. Next is the weapons program, in which we provide for development, production, storage, and surveillance of atomic weapons.

As you know, the Soviets are developing attack systems which can be brought to bear against wide areas of the free world and threaten the United States, its allies, and our forces.

Unfortunately, too, each succeeding attack system reduces substantially the warning we can expect, if any, and, therefore, the possibility of our deploying weapons to defend the threatened areas after warning.

Faced by this threat, we have given, and are continuing to give, the most intensive effort to the design of warheads which can be kept operationally ready, are safe, and will permit development of the most effective weapons systems. Heavy emphasis is being placed also on achieving both simplification in the design of weapons and their associated equipment, and multiple-use to reduce the number of types which must be stockpiled.

PRODUCTION OF ADVANCED TYPES

Production of advanced types is continuing at a rate which has been planned by the Defense Establishment and the Atomic Energy Commission.

TESTING

The estimate for testing in fiscal year 1960 is predicated on a continued maintenance of the test areas in a standby status except for limited tunnel construction at the Nevada test site to provide an underground test readiness capability should weapons tests be resumed.

Mr. CANNON. Mr. Chairman, if you will, I will be glad, in view of the fact that the last several paragraphs are not included in our committee version here and are off the record and three or four of the committee have not heard it—I will be glad if you will return again following, "Defense Establishment and the Atomic Energy Commission for several years * * *." Will you repeat that?

Mr. MCCONE. Yes.

Mr. CANNON. I will say to the committee this is off the record in the version before you.

Mr. MCCONE. The estimate for testing in fiscal year 1960 is predicated upon a continued maintenance of the test areas in a standby status except for limited tunnel construction at the Nevada test site to improve an underground test readiness capability should weapons tests be resumed.

Mr. CANNON. You may proceed. Thank you.

REACTOR DEVELOPMENT

Mr. MCCONE. As you know, our reactor development budget covers both civilian and military programs. The present state of our knowledge in civilian power reactors has been reviewed carefully during the past year. We have taken every advantage of the views of industry and of the Joint Committee on Atomic Energy as set forth in their hearings and reports.

Further, we have obtained the advice of a number of the most highly qualified experts who served the Commission as an ad hoc committee. This report was received on January 2, 1959, and made immediately available to all.

We have now completed what I call the first phase of development of civilian power reactors. Five years ago this Commission, with the approval of the Joint Committee as well as this committee, initiated its first formal civilian nuclear power program. There have been waves of optimism and pessimism as development progressed during these 5 years.

POSSIBILITY OF POWER AT COMPETITIVE COST

Now there seems to be a steadily improving basis for projecting our technology into actual plants which are capable of producing power at costs competitive in at least some high-cost areas of the United States and foreign countries.

The current state of technology for large commercial plants is clearly indicated by the design studies recently completed in accordance with our authorization legislation of last year. These studies estimate that for our most fully developed types of reactors—the pressurized water, boiling water, and organic cooled—power could be produced at a cost of 8.3 to 9 mills per kilowatt-hour. However, each

study indicated that further research and development is needed before such plants could be built.

From surveys of the Federal Power Commission, we would expect that when large-scale nuclear plants can generate power at 7 to 8 mills per kilowatt-hour, there would be a market in the United States for a few nuclear plants in the high cost areas. In Europe and in certain other parts of the world where the costs of conventional fuel are higher than in the United States, such plants could be competitive more quickly.

Thus, we see a situation in which we are rapidly closing the gap, but where further work is needed before competitive costs can be achieved even in the high cost areas. We believe the projects contained in the present authorization bill will help show the way to such costs and to even lower costs which would be competitive in many areas.

OBJECTIVES FOR NUCLEAR POWER PROGRAM

Objectives for our nuclear power program are now widely agreed upon. Further, the Commission has defined its role of major responsibility and intends to exercise vigorous leadership in moving toward our goals.

To achieve our goals we emphasize the construction of power generating prototypes during the developmental stage. They offer the most rapid and economical approach to demonstrating technical progress.

They require less time to finance, engineer, and construct than do large plants. Moreover, when they are placed in operation they are more flexible and, therefore, are most advantageous for proving out technical advances.

EXPERIMENTAL PROGRAM

The Commission's experimental program will continue to emphasize the following reactor types: pressurized water, boiling water, organic-moderated, sodium graphite, and fast breeder. The gas-cooled reactor type will receive increased emphasis. For fluid fuel reactors we are focusing our attention beyond fiscal year 1959, on those specific fluid fuel concepts which promise successful thermal breeding.

At this time, the aqueous homogeneous concept appears to offer the best breeding potential.

The 1960 authorization bill provides for a flexible experimental prototype gas-cooled reactor. This project is in lieu of the gas-cooled power reactor in last year's authorization act.

Other new projects in the bill for Commission construction are the experimental organic cooled reactor, which is a facility for testing various types of fuel elements and organic coolants, and an experimental reactor to produce process heat for industrial purposes.

MODIFICATION OF SHIPPINGPORT REACTOR

The budget would also permit a significant modification of the Shippingport power reactor, the first full-scale power reactor in the United States. This modification would increase the reactor's power output from 100,000 kilowatts to 150,000 kilowatts at a cost to the Government of $5 million.

The modification would be made only if the operating utility provides the additional electric generating facilities. A proposal has been received from the utility and is now under study.

During fiscal year 1960 the AEC will have in operation six experimental reactors and the Shippingport power reactor. Two additional experimental reactors will be under construction; one for development of components for heavy water reactors, and one for development of a plutonium fuel cycle. Although not a primary purpose, these plants will produce 165,000 kilowatts of electric power.

PRIVATE CONTRIBUTIONS

Private industry is also making important contributions to power reactor technology—in a number of instances without any direct financial assistance from the Government. Two exclusively private industrial projects are under construction: the pressurized water reactor of the Consolidated Edison Co. at Indian Point, N.Y., and the boiling water reactor of the Commonwealth Edison Co., at Morris, Ill.

Construction of a boiling water reactor is scheduled by the Pacific Gas & Electric Co. to start in the spring of 1960 at Humboldt Bay, Calif. Together with other projects undertaken by industry, 400,000 kilowatts of electric power will be produced in reactors financed entirely by them.

COOPERATIVE PROGRAM

One of the major means of demonstrating practical results of the Commission's direct research and development program is through the cooperative arrangements between Government and industry for reactor construction. The objective of this program is to provide important data based on actual operation of prototypes, often using full-scale components, connected to an established electric power distribution system.

At present there are eight cooperative projects for which contracts have been signed and one proposed project which is included in the authorization bill. These projects have a total capacity of 475,000 electrical kilowatts.

Therefore, a total of 22 plants are now planned and will produce over 1 million kilowatts of electricity.

The authorization bill provides for undertaking new projects under both the second and third round of the power demonstration reactor program. The second round provides arrangements suitable for use with cooperative and publicly owned utilities.

Under its terms the Government builds and owns the reactor and sells steam to drive the turbogenerator owned by the utility. The authorization bill provides for the construction of two reactor prototypes under this arrangement. One may be a small power reactor and the other an intermediate size reactor.

The third round provides for assistance to prototype projects to be constructed by private industry. Assistance is limited to research and development and to waiver of use charges for fuel and heavy water. This assistance may cover a boiling water reactor and an intermediate size reactor.

SMALL NUCLEAR SUPERHEAT REACTOR

With respect to project 60–e–15—a small nuclear superheat reactor—we believe, as does the Joint Committee, that nuclear superheat will reduce power costs from boiling water and pressurized water reactors by increasing the temperature of the steam produced in the reactor, therefore enhancing its value for the operation of the turbogenerating equipment.

Hence, intense work in this area is necessary. A design and engineering study of a reactor capable of producing superheated steam in the nuclear reactor, which study was authorized last year, will be completed in November. This will be followed immediately by necessary research, development, and initial engineering work on the project.

This work will consume a year's time; and, if the results are satisfactory—and we are confident they will be—we will then proceed with the detailed designs and the construction of the reactor. Our budget requirements for this year make specific provision for funds for the necessary development work mentioned above.

If this work justifies our present optimism, next year we plan to request funds for the construction of the reactor. This work, together with other nuclear superheat projects now underway, will insure rapid progress in this area consistent, in our opinion, with a technically sound program.

COOPERATIVE PROPOSALS

The Commission will specify the type, size, and other major characteristics of plants for which we invite cooperative proposals. In the event the Commission solicits proposals for any prototype and no satisfactory proposal is received, the Commission may, if the project is still deemed desirable, proceed with the design, construction, and operation of the prototype at a Commission installation.

We hope that, as these projects go forward, some utility groups, both public and private, will determine without solicitation from the Commission that they should build nuclear powerplants. Funds are requested to provide research and development assistance for nuclear powerplants proposed by industry if the Commission determines that such projects will make significant contributions to our objectives.

We believe the program which can be implemented in accordance with the authorization bill is sound and forward looking.

Close work between the Joint Committee and the Commission in the development of this program has been fruitful. I believe both groups are gratified with the results. Now we are completing our plans and preparations. We will pursue this program vigorously as soon as we have authority to do so.

INTERNATIONAL COOPERATION

Next, I should mention our program of international cooperation, which includes support of Euratom, the International Atomic Energy Agency, and nations with which we have bilateral agreements. In the development of reactors utilizing heavy water, the Commission plans to expand its already extensive program of cooperation with Canada.

Our international cooperative programs should do much to speed up the development of reactor technology, and we hope that economical nuclear power in certain high-cost areas abroad may be achieved within 5 years.

The largest of these international efforts is the Euratom program. In December, the Commission and Euratom announced their jointly financed research and development program and invited proposals. At the present time 110 specific proposals have been received for work aimed primarily at improvement of reactor performance and reduction of fuel cycle costs.

Also, invitations were issued in April to the utilities of the Euratom countries to submit by the fall of 1959 proposals for the construction of power reactors. At last report seven letters of intent to submit proposals had been received. Five are for projects scheduled to be in operation in 1963 and two are for projects to be in operation in 1965.

NUCLEAR POWERED MERCHANT SHIPS

Yet another area of civilian reactor development is propulsion of merchant ships by nuclear power. In these efforts the Commission is responsible for reactor development and the Maritime Administration is responsible for the ship. The launching of the first nuclear merchant ship, the NS *Savannah*, on July 21, will mark an important milestone in this program. The *Savannah* will be propelled by a pressurized water reactor system. We are also instituting studies leading to development of a boiling water reactor system. Also a gas-cooled reactor, closed-cycle gas turbine propulsion system, is under study. This particular system offers great potential in compactness and relatively light weight.

The entire reactor development effort for both military and civilian needs is supported by research and development on reactor safety, management of radioactive residues, and fuel cycle improvement.

FUEL CYCLE DEVELOPMENT

Fuel cycle development offers great possibilities for decreasing the cost of generating power from reactors by achieving longer fuel life, greater burnup, and better resistance to damage by corrosion, radiation, and heat.

Another supporting area is that of radiation testing. Testing reactor materials and components in the radiation environment to which they may be exposed is fundamental to success. We have sought and are now considering industrial proposals for supplying test irradiation services.

However, we recognize the possibility that specialized demands of the Government program, particularly for naval reactors, may also require the construction by the Government of a high flux test reactor in fiscal year 1961.

MILITARY REACTORS

A little over half of our total estimated operating costs for our reactor development program are for projects to meet military needs.

The Commission has given careful scrutiny during the last few months to the program for development of a nuclear powerplant for

use in manned aircraft. Progress in this program over the last few years has appeared to be slow, and it has been expensive.

I believe we must bear in mind, however, that the technical objectives of the program are very difficult and that there has been significant doubt whether the objectives could be achieved within a reasonable time. Research and development in basic materials, and their fabrication into components which will withstand the high temperatures and stresses essential to a high-performance powerplant, have taxed the ingenuity and imagination of our scientists and engineers.

We are also proceeding with experiments to determine the feasibility of the use of nuclear power for the propulsion of rockets—Project ROVER—and ramjet missiles—Project PLUTO.

I am sure that all of you are familiar with the SNAP project to develop systems for nuclear auxiliary power. These systems are small, lightweight, package power sources initially developed for satellite instrumentation. Two main approaches are under development.

One utilizes the heat from the decay of a radioisotope, and the other uses a small reactor. The remarkable success of our recent SNAP III device has led to serious consideration of SNAP units for uses ranging from underwater applications to the eventual possibility of propulsion in space.

The range of the developments for the application of nuclear power to the propulsion of naval vessels has by now expanded from the *Nautilus* to include a variety of types of submarines and surface ships. Our naval program includes five land prototypes: three are already in operation; the fourth will be operating in fiscal year 1960, and the fifth in fiscal year 1961. U.S. leadership in naval nuclear propulsion is demonstrated by the authorization of construction, through fiscal year 1959, of 33 nuclear-propelled submarines and 3 surface ships. Six of the submarines have already been commissioned. The surface ships consists of a guided missile cruiser, an aircraft carrier, and a destroyer.

During fiscal year 1960 the development of a natural circulation pressurized-water system for naval use will be in progress. This type offers significant advantages in plant simplification. increased reliability, and inherent safety. A land prototype facility would be constructed.

The objective of the Army reactors program is to develop a family of reactor systems to fulfill many different military requirements for nuclear powerplants at remote locations. The major effort in fiscal year 1960 for pressurized-water plants will be the development of improved cores and plants manufactured in easily transportable sections for rapid assembly.

The operation of the small boiling water reactor prototype at the National Reactor Testing Station will be directed toward determining operating costs, plant capabilities, reliability, and inherent safety. A land prototype facility would be constructed.

A gas-cooled reactor experiment will be operated at the National Reactor Testing Station to explore the possibilities of closed-cycle systems which might be easily transportable and which could be operated without access to a water supply.

Experimental work is also being directed toward development of a very compact fast reactor system.

PHYSICAL RESEARCH

Next, in order of our budget, is physical research, the quest for basic understanding of matter and energy. Research is being pushed into areas more and more difficult to explore. With the high-energy particle accelerators, we are finding out more about the elementary particles of the atom. Studies are being intensified to learn how materials behave under radiation bombardment and under the heat intensity necessary for high-performance reactors.

The 1960 estimates for physical research include the work on controlled thermonuclear reactions, Project Sherwood. Previously, this has been presented as part of the reactor development program. The day may come when man will use the knowledge obtained with these funds to get his major energy requirements from the heavy water present in all ordinary water.

LINEAR ELECTRON ACCELERATOR

Not included in our request are funds for the construction of a linear electron accelerator which the President recently announced would be constructed at Stanford University. The Atomic Energy Commission was assigned responsibility for building this accelerator, and on May 27 we forwarded to the Congress a request for authorizing legislation in the amount of $105 million for construction of this machine.

Our estimates also provide for work on the machine during fiscal year 1960. Authorization hearings are now planned on the subject by the Joint Committee on Atomic Energy for early July.

BIOLOGY AND MEDICINE

Let us turn now to our vitally important biology and medicine program. The Commission has long been greatly concerned over the possible effects of radiation on human life, especially the low level exposures encountered in our rapidly expanding atomic energy industry and the radioactive fallout from nuclear weapons tests. Even without the problems associated with the testing or wartime use of nuclear weapons, the nuclear age brings with it the problem of dealing with low-level radiation, that is, levels which are a small fraction of the natural background radiation which is always present.

At the same time that our scientists investigate radiation effects, we must seek greater public understanding of what is already known. For this reason, we were most pleased to take part in the recent week-long Joint Committee hearings on this subject.

GENETIC EFFECTS OF LOW-LEVEL RADIATION

We have been in the past 2 years been able, through the support of your committee, to intensify our research program on radiation effect. I can now report that scientists at our Oak Ridge National Laboratory have shown that the genetic effects of low-level radiation, though very real, may be only one-fourth as great as prior estimates which were based on high-level exposures. More work along these lines must be done, especially with respect to bone cancer, and leukemia where simi-

lar differences may develop. As you know, these vital studies are costly and time consuming and involve literally hundreds of thousands of animals.

Our fallout studies were also intensified during the past 2 years. As a result, the statement of the fallout prediction panel at the recent hearings indicated more complete agreement among the experts than was possible 2 years ago. This program must be carried on for at least 2 more years with an even greater effort called for in fiscal year 1960.

In fulfilling our responsibilities to explore atomic energy and its tools and byproducts in the biomedical and agricultural sciences, we have this past year completed the Brookhaven permanent medical center with its unique reactor devoted entirely to medical research and the treatment of cancer. This, we believe, constitutes a milestone in the peaceful uses of the atom.

This many-faceted program of research is essential to our health and safety, and must continue at an increasing pace.

TRAINING, EDUCATION, AND INFORMATION

Training, education, and information activities are designed to broaden knowledge of nuclear technology at home and abroad. These funds are used to provide specialized teaching equipment for schools, to publish technical books and reports, to conduct special courses for faculty members and foreign nationals, to award fellowships, to participate in international exhibits, and similar important undertakings.

We believe that each year the Commission and its contractors working with the entire community of science and industry, are pushing back the frontiers of knowledge. Each year brings a keener appreciation of the limitations of current knowledge, and we recognize that only by continued hard work can we hope to maintain our place in the expanding world scientific community.

We place great importance on the support of universities and on training of both graduate students and high-school teachers. Continuing leadership in the scientific world clearly demands a growing body of science students, practitioners, and teachers in this Nation. Certainly, this committee's understanding of this challenge has been a source of great encouragement.

CIVILIAN APPLICATION OF ISOTOPES AND NUCLEAR EXPLOSIVES

Our next budget program is entitled "Civilian Application of Isotopes and Nuclear Explosives," and is set forth separately in the estimates for the first time this year.

This program is aimed at speeding up realization of the enormous potential which lies in the nonpower uses of atomic energy. We believe that additional hundreds of millions of dollars of industrial savings can be achieved through more widespread understanding of the techniques available. Medical uses of isotopes for research, diagnosis, and treatment are of increasing importance, and certain applications have now become routine.

The effort to investigate the possible peaceful uses of nuclear explosives is carried on under the name of Project Plowshare. Several

small-scale experimental detonations are in the exploratory planning stage, but of course the decision to proceed with any nuclear detonation would take account of the status of negotiations on weapon test suspension.

Possibilities being studied include the excavation of harbors and canals, the recovery of oil from deep-lying shale and tar sands, the production of isotopes, and the generation of useful power.

COMMUNITIES

As in the past, our estimates provide for the operation and administration of the three AEC communities of Oak Ridge, Tenn., Richland, Wash., and Los Alamos, N. Mex. Under the community disposal legislation enacted for Oak Ridge and Richland, most of the real estate in these communities has already been sold to the residents or other purchasers.

Municipal incorporation has taken place in the case of Richland and Oak Ridge. At Richland, schools and hospitals, and municipal services such as fire and police, have been transferred, but agreements for the transfer of utilities, such as electric power and sewage, and the remaining municipal services have not yet been completed. At Oak Ridge, which only recently incorporated, no transfers have taken place.

Because of its unique character and location, the Commission will continue to have responsibility for the operation of the town of Los Alamos, N. Mex.

PROGRAM DIRECTION AND ADMINISTRATION

Our final budget category is program direction and administration. This covers the personnel and administrative costs of the Commission.

For the most part, the performance of program activity undertaken by the Atomic Energy Commission is carried out by contractor personnel, which number over 100,000 at the present time. A relatively small number of AEC personnel, about 2,000, are also engaged in direct program activity, an example being the operation of weapon storage sites.

About 4,700 AEC employees are responsible for the overall formulation, planning, and supervision of the Commission programs. Most of these employees are located in the 12 operations offices situated in various parts of the United States.

Their activities include contract administration relating to production, research and development, and construction.

Further, they develop standards and control measures for internal security and for protection of Government funds and property. They direct efforts aimed at encouraging the civilian uses of atomic energy, perform licensing activities, and investigate licensees' operations to insure compliance with regulations.

Relatively new are our activities dealing with the international aspects of atomic energy, such as the programs of Euratom, the International Atomic Energy Agency, and the nations with which we have bilateral agreements.

We need additional staff to meet our growing responsibilities for international safeguards and control of nuclear materials and equip-

ment which we furnish other countries. We must also increase our staff for the regulation and inspection of the increasing number of domestic licensees. Increases are also necessary to keep pace with the continuing expansion of work in the field of international cooperation; to complete the initial staffing of two operations offices at Pittsburgh and Lockland; and finally, to supervise expanding technical programs in the field of reactor development and the construction of the new production reactor at Hanford.

That concludes my statement, Mr. Chairman. Unless the committee has questions for me, I suggest that General Luedecke direct the remainder of our presentation, in which we will take up each of our budget programs in whatever detail the committee wishes to hear.

FOREIGN ATOMIC ENDEAVOR

Mr. CANNON. I notice that your total budget operating expense appropriation for an estimated obligation of more than $2½ billion during fiscal year 1960. That is a stupendous sum, but of course, you have a stupendous problem. Is any other country in the world devoting the same amount of energy and resource to this problem that the United States is?

Mr. MCCONE. I do not know what Russia is devoting to this problem. The British, while they have a substantial program relative to their level of government activities is just a fractional part of ours.

Mr. CANNON. Does the British program approximate any amount such as this?

Mr. MCCONE. No.

Mr. CHAIRMAN. So far as you are aware, this is the largest amount?

Mr. MCCONE. By far, sir.

Mr. CANNON. But the Russians are producing powerplants, hydroelectric plants, which is said by Members of the Congress who visited them to dwarf the largest hydroelectric plants in the United States.

It is possible that it they are excelling us, in this area they might also be proceeding on a similar scale in other fields.

Mr. MCCONE. They have, as nearly as we can determine, quite a substantial program in nuclear power field. We, furthermore, believe that most of their plants are so-called dual purpose plants which not only produce electricity but also produce plutonium for their weapons program.

Mr. CANNON. Do you think it is possible that they are as advanced in this respect as we were with our program?

Mr. MCCONE. I cannot answer that, sir. I feel that they probably have a larger program, measured in kilowatts. Whether they have as broad a field of research and development as we have, I don't know. I would question it.

URANIUM SUPPLY AND PRICE

Mr. CANNON. You are now receiving supplies of uranium in excess of your yearly requirements?

Mr. MCCONE. That is correct.

Mr. CANNON. As the supply increases what effect does that have on the price? Is price governed supply and demand?

Mr. McCone. Our price has come down, sir. In each successive negotiation the price of the uranium oxide has decreased. The expectancy is that we will have delivered to us under existing contracts, which we must honor, more uranium oxide in each of the next 3 years than we need as feed stock for our plants.

After that, our supply, which is under firm contract—drops off very rapidly. What we are trying to do is to stretch out some of these contracts and kind of level off the curve a little bit and minimize this intake in excess of our requirements and we have had some success in doing that.

Mr. Cannon. You are still stockpiling and you have been stockpiling at about the same average rate for the last 3 years?

Mr. McCone. No. We are running above our average of the last 3 years. I think—well, as I remember, the figure is about 35,900 tons against a requirement of 33,000 tons. Next year will be about the same and the year after about the same as that and then it drops off. I think this is the peak. I think last year was a little lower.

Ed, do you have the exact figure there?

Mr. Bloch. That is correct.

Mr. Johnson. Purchases will be 33,000 tons of U_3O_8 in fiscal 1959, which is in balance with the requirements. For fiscal 1960 the purchases are estimated at 35,915 tons, and in 1961 they will be around 36,000, still above the 33,000 requirement.

Mr. Cannon. You are stockpiling in anticipation of what needs?

Mr. McCone. We have no indicated need at all, sir. We are accepting it because we are required to take it under the contracts that were negotiated some years ago. The deliveries under those contracts are exceeding speculations, somewhat.

As you will recall, it was only 3 or 4 years ago where the problem was to get enough uranium. Like so many things in this world, the supply and demand changed position rather quickly and as a consequence, we have an oversupply now. We corrected the situation by canceling all open commitments as of November of last year. Now, it is a matter of taking only that material which is under firm contract.

Mr. Cannon. Well, our stockpiling policy has been for the last year or two, and is now, with what purpose in view? You are constantly increasing the amount stockpiled. What use do you anticipate?

I would like to ask right there, too, is there any appreciable deterioration?

Mr. McCone. No, there is no appreciable deterioration. There is no definite stockpiling policy, sir.

Mr. Cannon. But you are accumulating a reserve supply?

Mr. McCone. Yes.

Mr. Cannon. Can you envision situations under which that supply will be needed or will be used?

Mr. McCone. We could very easily run it to weapons for that matter. What we are actually doing is processing the uranium oxide. It could be very easily run to weapons and used up but that would be a matter of some cost.

Mr. Cannon. You are collaborating in this work with the War Department?

Mr. McCone. Yes. We develop and produce the weapon that they require.

Mr. CANNON. Do you make them to their specifications?

Mr. MCCONE. We make them to their need. They tell us that they need a warhead of a certain yield and a certain limitation of weight and then we go to work and develop that for them.

Mr. CANNON. Do you test them or do they test them?

Mr. MCCONE. We test them. They furnish the logistics support for the testing operating; the engineering and scientific work is done very largely by us.

Mr. CANNON. Now, what you have said about war production is, I take for granted, classified, in view of the fact that you have not included it in this mimeographed copy.

Mr. MCCONE. That is right. This is classified information.

Mr. CANNON. The committee is not supposed to talk about that to the uninitiated?

Mr. MCCONE. That is correct.

CIVILIAN POWER REACTORS

Mr. CANNON. In discussing the development of civilian power reactors, none of the data is classified?

Mr. MCCONE. No. That is not classified.

Mr. CANNON. You say you have completed the first phase. Tell us something about that first phase.

SHIPPINGPORT REACTOR

Mr. MCCONE. Well, the first important plant that was built was the Shippingport plant. That plant has been in operation now for about 2 years. That plant has operated very successfully and it has served a very useful purpose in the evolution of nuclear power. It has been operated at 60 megawatts electrical, although it was designed for 100 megawatts electrical.

We now find that through efficiency that has evolved that we can increase the power output of that plant to 150 megawatts electrical.

Mr. CANNON. That is the plant constructed under the direction of Admiral Rickover?

Mr. NCCONE. That is correct.

Mr. CANNON. At its initiation there was considerable apprehension expressed through the press and elsewhere that it might get out of control and being located in heavily populated centers could create a vast amount of damage. Apparently, those forebodings were ill-founded.

Mr. MCCONE. That is correct. This has been no problem of that type.

Mr. CANNON. There are now no problems in construction; you feel perfectly safe in building these reactors?

Mr. MCCONE. Yes, we feel perfectly safe. Of course, we have a very exacting procedure, as you know. The location of a reactor is studied and reviewed by a special reactor safeguards committee that are very exacting and careful in analyzing the location and the environment surrounding it and so on and so forth.

Then, the reactors are designed so that if an accident did occur, irrespective of how remote the possibility is, there is a containment shell around the reactor so that if any fission product is released it

will be contained within this reactor shell. You are familiar with that type of construction.

Mr. CANNON. Certainly, in your attempts to build the reactor you had some apprehension as to the danger which might be incurred. You made previous efforts to build a reactor? This is not the first one you attempted to build?

Mr. MCCONE. Well, the first commercial size reactor was the Shippingport reactor. That was the first one, yes. There were some experimental reactors built prior to that time.

Mr. CANNON. I am rather impressed by the fact, Mr. Chairman, that Admiral Rickover built this first reactor under conditions which involved many obstacles and that he also powered the *Nautilus* when authorities and experts said it could not be done. He must be a rather remarkable man.

Mr. MCCONE. I think he is most remarkable and I think he and the men associated with him have done a great job and have made a great contribution to the security of this country and to its progress in this field.

Mr. CANNON. I notice that he, speaking very modestly of what he has done, always includes, as entitled to share the credit, those associated with him. But the truth about the matter is that those associated with him have worked under his direction.

Mr. MCCONE. I think that is true.

REACTOR SALES IN WORLD MARKETS

Mr. CANNON. You have a domestic market and you have a foreign market. Originally, we concerned ourselves largely with the foreign market and there was considerable disappointment when foreign nations instead of buying our reactors bought English reactors. Have you remedied that matter? Are you now sharing the world market with English production?

Mr. MCCONE. We are sharing the world market, yes. Our manufacturers have been successful in negotiating some firm contracts. The British likewise, have been successful in getting some contracts. The most recent contract that was awarded, was secured by the General Electric Co. in competition with three or four British companies.

Mr. CANNON. Where is that to be erected?

Mr. MCCONE. That is in Italy. They and one or two other American companies were lower than the British companies.

Mr. CANNON. Was the contract awarded on the basis of competitive cost or competitive efficiency?

Mr. MCCONE. It was a little of each, sir. I think on a straight, as I recall—and I am just speaking now from memory—on a straight evaluation of the dollar capital cost, the General Electric Co. was not low. There was one other American company that was a little lower, but when all of the operating factors were taken into account, the General Electric Co. was given the award because all things taken into account, their proposal was more attractive to the power company than any other.

Mr. CANNON. Japan has bought her reactors exclusively from England?

Mr. McCone. They have bought, so they report to me, one reactor from England. They are planning now to buy a reactor from this country.

Mr. Cannon. What about Brazil?

Mr. McCone. Brazil planned or let me say, an American interest planned to build one or two reactors in Brazil but found that because of the high cost of power, they being small reactors, it was not economically feasible and they dropped the project.

Mr. Cannon. It was not to be built with local capital?

Mr. McCone. I do not know that, sir, but I assume it would be at least part local capital.

STATUS OF DOMESTIC MARKET

Mr. Cannon. How has your domestic market developed? What demands have you here in the United States?

Mr. McCone. Our domestic market has been very disappointing. It has—to me, and I think to the other Commissioners—for the reason that the plants in their present design, with their high capital cost as compared with the conventional powerplants and the cost of fuel and the fabricating of it, and so forth, the power costs have been higher than can be obtained from a conventionally fired coal or oil plant.

Now we hope that through the program that we are developing here to correct this, to close the gap between the cost of nuclear power and the cost of conventional power. The studies that I mentioned in my statement, which were completed last spring, and had been authorized by the Joint Committee and this committee the year before, evidenced a very much smaller difference between nuclear power costs and conventional power costs than have been assumed prior to the issuance of those reports. Now those reports will have their impact and I am sure that the utilities, both public and private, will have an increasing interest in building plants. There has been a wave of pessimism over nuclear power costs and I sense a change.

Mr. Cannon. Is that confined to the United States or is it worldwide?

Mr. McCone. Well, it is confined to the United States for one reason and it is worldwide for another reason. Let me first deal with the United States.

There was a feeling that nuclear power costs were going to be exorbitantly high but the studies and reports of which I speak have demonstrated that they are marginally high. There are a great many people now who can see with some, but not an impossible amount of development, nuclear power costs can be brought down so they will be competitive in the higher cost power areas in the United States.

Then, it is expected that nuclear power will progressively intrude in other areas. It is significant that the Pacific Gas & Electric Co. elected to build a nuclear powerplant in the northern part of California, which is a high-cost power area. They did it without any Government support and they did it presumably on a straight economic basis.

Other California power companies have projects under consideration at the present time. There is a Michigan company that announced only last Friday, after consultation with us, an intention to

build a 75-megawatt plant in northern Michigan. Perhaps you saw that announcement which I think appeared in Saturday's papers.

This is encouraging, but it does not represent a boom market to me.

Now, you asked a question about foreign countries. The long-range outlook for nuclear power in foreign countries is no different than it was a year ago or 2 years ago. There is a different short-range situation because of the excess of coal in practically all countries. You have read about that.

There is coal piled up above ground in England and in Belgium and in France and in Germany, and this has kind of dampened the immediate enthusiasm of the feeling of urgency. So I think the markets have slowed down a little bit in the foreign countries for a different reason than exists here.

CONTRIBUTIONS OF PRIVATE INDUSTRY AND GOVERNMENT IN CONSTRUCTION OF NUCLEAR REACTORS

Mr. CANNON. All your installations in the United States have been built largely with Government capital? You have worked with various private utilities, but in each instance the Government has provided the bulk of the money required.

Mr. MCCONE. Well, that is not true in all instances. Let me run down a few of the projects.

I mentioned the Shippingport project which was all Government funds for the nuclear part of the plant; the generating part of the plant was provided by private industry.

The next plant that will go on stream will be the plant of the Commonwealth Edison Co., at Dresden, Ill. This is a 180,000-kilowatt plant. It was built entirely of private capital. There is no Government contribution either for research and development, fuel, or anything else. That plant will be followed next year by the Yankee plant in Massachusetts. That plant was built with private capital but the Government, through the Atomic Energy Commission, provided, I think, $5 million for research and development assistance and also a waiver of fuel charges for a period of 5 years.

Then there is the Consolidated Edison plant up at Indian Point on the Hudson River. That is a big plant and was financed exclusively by Consolidated Edison.

There is another category of plants, such as the plant being built out at Hallam, Nebr., in which we are building the nuclear section and a local rural electrification group is building the conventional part of the plant and providing land and so forth. So this is proceeding under a number of different plans, and I think both Government and private industry are making substantial contributions in the way of money and energy and technical know-how, and so forth.

Mr. FOGARTY. In other words, Mr. Chairman, your answer to the chairman's question is that in your opinion more of these plants have been bulit with private funds than with Government funds since they have been started.

Mr. MCCONE. I would not think that, sir.

Mr. FOGARTY. Can you supply for the record a table giving the contributions of private industry and Government in research in the way of fuel cost, construction?

Mr. McCONE. Yes; I will do that. I could point out here that in my statement I stated that there are 165,000 kilowatts in operation now which represents exclusively Government cost. There are 400,000 kilowatts in three or four plants that were exclusively done by private industry. There are another 475,000 kilowatts that are cooperative programs between Government and either public or private utilities. So in terms of kilowatts, I suppose it would break out about 50–50.

Mr. FOGARTY. Let us get the dollar figure.

Mr. McCONE. I will get you the dollar figure.

(The matter referred to follows:)

Statement of U.S. Atomic Energy Commission concerning contributions of the Government and of private industry in the construction of nuclear reactors for power purposes

[Dollars in thousands]

	Electric kilowatts/net	Total estimated cost	Contributions	
			Government	Private
A. Financed entirely by private industry:				
Consolidated Edison thorium reactor	[1] 163,000	$90,000		$90,000
Vallecitos boiling water reactor	5,000	3,072		3,072
Dresden Nuclear Power Station	180,000	45,000		45,000
Humboldt Bay project	50,000	19,500		19,500
Total A	398,000	157,572		157,572
B. Financed by private industry with Government R. & D. assistance:				
Yankee Atomic Electric Co	110,000	63,480		
Research and development		5,400	$5,000	400
Construction		55,100		55,100
Fuel		2,980	2,980	
Power Reactor Development Co	90,000	86,385		
Research and development		23,667	4,450	19,217
Construction		59,015		59,015
Fuel		3,703	3,703	
Northern States Power Co	62,000	33,100		
Research and development		9,700	8,500	1,200
Construction		21,600		21,600
Fuel		1,800	1,800	
Carolinas-Virginia Nuclear Power Association, Inc	17,000	44,883		
Research and development		21,572	13,905	7,667
Construction		22,141		22,141
Fuel		1,170	1,170	
East Central-Florida West Coast-Nuclear Power Groups	50,000	57,011		
Research and development		29,592	11,646	17,946
Construction		25,885		25,885
Fuel and heavy water		1,534	1,534	
Philadelphia Electric Co	40,000	44,210		
Research and development		14,500	14,500	
Construction		27,210		27,210
Fuel		2,500	2,500	
Total B	369,000	329,069	71,688	257,381

See footnotes at end of table, p. 88.

Statement of U.S. Atomic Energy Commission concerning contributions of the Government and of private industry in the construction of nuclear reactors for power purposes—Continued

	Electric kilowatts/net	Total estimated cost	Contributions	
			Government	Private
C. Under cooperative arrangements with Government furnishing research and development assistance and financing cost of reactor:				
Hallam nuclear power facility	75,000	77,688		
Research and development		$26,165	$26,165	
Reactor		24,013	24,013	
Generating and supporting facilities		26,185		$26,185
Fuel		1,325	1,325	
Rural Cooperative Power Association	20,000	14,202		
Research and development		2,176	2,176	
Reactor		9,383	9,383	
Generating and supporting facilities		2,518		2,518
Fuel		125	125	
City of Piqua, Ohio	10,500	18,355		
Research and development		6,818	6,818	
Reactor		7,332	7,332	
Generating and supporting facilities		3,955		3,955
Fuel		250	250	
Shippingport Atomic Power Station	60,000	70,000	64,500	[2] 5,500
Total C	165,500	180,245	142,087	38,158
Totals:				
A	398,000	157,572		157,572
B	369,000	329,069	71,688	257,381
C	165,500	180,245	142,087	38,158
Grand total	932,500	666,886	213,775	453,111

[1] Excludes 104,000 kilowatts for oil-fired superheater.
[2] Includes $5,500,000 investment by private industry in the project.

FURNISHING FUEL TO PLANTS

Mr. RILEY. Mr. McCone, you outlined the various programs you have for supplying fuel. You have different contracts for these different plants?

Mr. MCCONE. That is correct.

Mr. RILEY. I would like to know the different methods by which you furnish fuel for the operation of these plants.

Mr. MCCONE. Under the law we can supply them the fuel for use for a period of 5 years with the waiver of the use charges. Under that arrangement they merely pay for the value of the fuel which is consumed and the cost of reprocessing that fuel when it is spent and must be removed from the reactor.

Now, in other instances where we do not give assistance in the way of fuel waiver we rent the fuel to them at 4 percent per year based on the value of the fuel and then charge them for the burnup, and also the reprocessing in our own chemical plants.

Mr. RILEY. Those are the only two methods by which you furnish them with the fuel?

Mr. MCCONE. At the moment, yes, that is correct.

Mr. RILEY. Thank you.

STATUS OF BRITISH PROGRAM

Mr. FOGARTY. Mr. Chairman, I was interested in one statement you made. Two or three years ago I remember we were told that England was away ahead of us in the development of some of these nuclear powerplants. One of the reasons that they were spending so much effort in that direction was because of the shortage of coal, but now they have an oversupply of it and that has stopped their forward progress, is that it?

Mr. MCCONE. No, it has not stopped their forward progress. I am told that they are inclined to review their program from time to time with respect to the short-range objectives, but I do not think there is any change at all in their long-range objectives. They seem to have a program of building over the next several years about 5 million kilowatts of nuclear power capacity.

This is particularly important to them because, as you know, their power is expensive and nuclear power, even in its early developed stage, is competitive. Furthermore, to the extent that a certain substantial percentage of their fuel is in the form of imported oil there is a saving from the standpoint of their foreign exchange balance. So they have two motives.

I have been over and gone into their program very carefully with them, visited a great many of their plants. I feel that they have a program that fits their unique situation but it would not fit our situation because the plants that they are building are attractive to them but would not be attractive to us.

Mr. FOGARTY. Why?

Mr. MCCONE. Because our power is so much cheaper. Our coal is so much cheaper and in various parts of the country our oil is so much cheaper that our power produced from those conventional fuels is far less costly to us than theirs.

Mr. FOGARTY. They have built a different type of plant, have they not?

Mr. MCCONE. They started out with a gas cooled graphite moderated reactor. This was attractive to them for two reasons.

In the first place it was relatively simple type of reactor to build and, secondly, it was a dual purpose reactor inasmuch as it produced electricity and also produced plutonium and they needed the plutonium for their weapons program.

We, starting with Hanford during the war, elected—and I think rightly so—not to build dual purpose facilities but to concentrate on plants that could be operated at optimum for the production of plutonium. This I think was a correct decision.

The scientists that worked on that at the time told me they weighed the Hanford design against the gas-cooled design that the British proceeded with and they were convinced that the water-cooled Hanford design was the proper design.

YANKEE ATOMIC ELECTRIC CO.

Mr. FOGARTY. You mentioned the Yankee Atomic Electric Co. That is one of these cooperative projects?

Mr. McCone. Yes, that is a syndicate of power companies up in that area.

Mr. Fogarty. You are going to contribute $4 or $5 million to research and development?

Mr. McCone. $5 million, I believe.

Mr. Fogarty. 1960 will complete your part of this program?

Mr. McCone. Yes, I think they expect to have that plant in operation in 1960.

Mr. Fogarty. Are you satisfied with the progress which this plant has made?

Mr. McCone. Yes.

Mr. Fogarty. I was led to believe that they are away behind in their progress.

Mr. McCone. Dr. Pittman can answer that question.

Dr. Pittman. They may have slipped a little, but they are not way behind.

Mr. McCone. They may be behind their anticipated schedule——

Mr. Fogarty. I am talking about 5 years ago, 6 years ago.

Mr. McCone. Yes, I think they are behind that. In fact, I think all these plants are behind where they hoped to be when they started out 5 years ago.

Now, there are several reasons for it. In the first place, it took quite some time for them to negotiate their arrangements with the Commission. This was a new law. We were just unlocking the secrets of the atom and it took quite a while. There were questions of liability and indemnification and all these things.

Then, they had quite a time with their financing, putting these syndicates together. There were a great many tax problems and other things that arose. Concurrently, they were having quite a time harnessing the atom and getting it under control. It was a more difficult problem than was thought.

But once those things were riveted down, Dresden and Yankee have proceeded under a good schedule.

Mr. Fogarty. And you expect that this plant will be completed in fiscal year 1960 and in operation?

Dr. Pittman. It is supposed to be completed in June or July 1960 and go critical shortly thereafter, sir.

Mr. Fogarty. Then what happens? Can you give us a brief explanation of just what you expect from this development? I notice on page 76 of your justification you have the location and type of reactor, heat output, amount of fuel and all of these figures.

Now, just what do they mean? Can someone go down that list and tell me with respect to what can be expected out of this development?

Mr. McCone. I know what the Yankee people expect. They expect shortly after the plant is put on stream it will gradually be brought up to full power and they will put that power on their lines and sell it for revenue. They expect that over the next several years they will progressively improve their operation by replacing their initial core with a second core and that second core will increase the power output from 110,000 kilowatts to, I believe, 130,000 or 135,000. If they are successful in meeting their cost estimates, and also successful in meeting their estimates of operation, and so forth, they will be producing power which, while initially higher cost than other

sources of power, nevertheless, will have started them in this area which they consider economical.

COST OF NUCLEAR POWER

Mr. FOGARTY. You said a short while ago that the study which you have just completed shows that the difference in cost in output between nuclear and conventional power is much smaller than it was 4 or 5 years ago.

Mr. MCCONE. Yes, that is correct.

Mr. FOGARTY. There is a big difference in the cost of power in New England and some areas of California or Tennessee Valley.

New England is the highest in the country, is it not?

Mr. MCCONE. Maybe California is a good competitor because we have in parts of California quite high cost.

Mr. FOGARTY. I guess it might be double the cost of what it is in places like Tacoma, Wash., or in the TVA area.

Mr. MCCONE. New England is one of the highest cost areas and parts of California.

Mr. FOGARTY. You mean to say there are places in California that are higher than New England?

Mr. MCCONE. I think that the cost of power in the northern California area, before you get so far north as to get into the influence of the Bonneville Power Authority, that the cost of power is just as high as it is in New England.

Mr. FOGARTY. Take the results of your study where the costs have been much narrower than was thought. How do you think the cost between the development of this nuclear power by the Yankee Atomic Electric Co. will compare with the average cost of conventional power in New England?

Mr. MCCONE. As I recall the figures, the cost of power from Yankee will be in the order of 14 to 16 mills on the initial core and I think they have hopes that that might come down to 10 or 12 mills on the second core.

I am speaking now from memory and I would like the privilege of correcting that figure if it is substantially in error.

Dr. PITTMAN. That is correct, sir.

Mr. MCCONE. Now, a new Yankee plant would develop lower cost, but it would do it for three reasons: In the first place, we know now how to get a higher, a more efficient burnup of the fuel itself; secondly, we know how to build plants of more simple design and, therefore, less capital cost; and, third, we would build a larger plant than this and, therefore, would have a lower overall operating cost.

Mr. FOGARTY. How much cheaper would the power be?

Mr. MCCONE. As I mentioned in my statement, the studies which we have completed indicate costs in the order of 8.3 to 9 mills.

Mr. FOGARTY. What is the average cost in New England for conventional power?

Dr. PITTMAN. About seven, I think. Seven to eight.

Mr. FOGARTY. So it is getting into a real competitive area so far as New England is concerned?

Mr. MCCONE. That is right.

Mr. FOGARTY. What does that mean to you?

Mr. MCCONE. That means that they will build more nuclear plants.

Mr. FOGARTY. They will?

Mr. MCCONE. Yes. I think the Yankee people have every hope that future developments on their grid will include nuclear plants.

Mr. CANNON. Mr. Riley?

Mr. FOGARTY. May I ask one further question?

Mr. CANNON. Mr. Fogarty.

FELLOWSHIPS AND GRANTS TO SCHOOLS

Mr. FOGARTY. Under your justification for training, information, and education—when you talk about fellowship programs and scholarships and aid to various schools of learning, is that a form of aid to education?

Mr. MCCONE. I think it could be considered as such; yes.

Mr. FOGARTY. Is your fellowship program similar to the Defense Educational Act?

Mr. MCCONE. I cannot answer that.

Dr. DUNHAM. You mean taking persons from the armed services and assigning them someplace?

Mr. FOGARTY. No.

Mr. MCCARTHY. I think, Mr. Fogarty, the fellowship programs we have here are highly specialized in terms of training in disciplines of importance to the AEC such as nuclear science and engineering, and radiological physics.

Mr. FOGARTY. Are you giving fellowship or training grants to medical schools?

Dr. DUNHAM. We give equipment grants to medical schools for training purposes.

Mr. FOGARTY. Not for any teaching purposes?

Dr. DUNHAM. We pay tuition for fellows who receive the special AEC fellowships, but we do not directly give a grant to the school for a course.

Mr. FOGARTY. What about aid to hospitals?

Dr. DUNHAM. The same way. It is either tied to a research project there or is supporting laboratory work in some form or other. We do not give direct aid to hospitals in the same sense that the Public Health Service does.

Mr. FOGARTY. You make grants of any kind?

Dr. DUNHAM. We make grant type research contracts which are very similar to Public Health grants.

Mr. FOGARTY. Do you make any grants to medical schools?

Dr. DUNHAM. Of research-type contracts and equipment grants. We do grant equipment if the school has a course in radiological physics, in radiation biology and that sort of thing. It is quite similar to the equipment grants by our Reactor Division for the engineering schools.

The school has to demonstrate that it has a course and then we will provide certain equipment up to $75,000 worth in any given instance.

Mr. FOGARTY. Upon application?

Dr. DUNHAM. Upon application, yes.

Mr. FOGARTY. Who OK's the application?

Dr. DUNHAM. The ones in the Division of Biology and Medicine are reviewed by a special advisory committee of experts in teaching and education.

Mr. FOGARTY. You pay the salaries of any teachers in medical schools?

Dr. DUNHAM. Only indirectly, as part of their activities are devoted toward work under a research contract arrangement.

Mr. FOGARTY. Isn't that the same with teaching hospitals?

Dr. DUNHAM. That would be the same thing.

Mr. FOGARTY. It is in a way an aid to education, an aid to medical schools?

Dr. DUNHAM. We believe very definitely.

Mr. FOGARTY. Have you had any complaints, any problems?

Dr. DUNHAM. Only that the people would like us to do more of it.

Mr. FOGARTY. Do you think more should be done?

Dr. DUNHAM. In the equipment grants we are running away behind the demand.

Mr. FOGARTY. That is mostly money but what about facilities? Do you provide any funds for the construction of facilities or the modernizing of present facilities?

Dr. DUNHAM. We do a certain amount of that but it is always, again, tied to a specific research project that is of interest to the Atomic Energy Commission program. We don't make general grants for refurbishing the labs.

Mr. FOGARTY. There has not been any organized or sporadic opposition to this form of aid to education medicine that you people are practicing?

Dr. DUNHAM. Not so far as I know.

IMPROVED CORES

Mr. RILEY. Mr. Commissioner, in your discussion with Mr. Fogarty you mentioned the fact that you had developed, I believe, a more efficient heating element or burning. It is possible to substitute that in the present reactors and use the same generating machinery?

Mr. MCCONE. Yes, that is correct, Mr. Riley, and that is done. I mentioned that at Shippingport we are increasing the capacity from 100,000 kilowatts to 150,000 kilowatts. That is being done in the same reactor by adding a more efficient core and some additional pumping equipment to increase the volume of water than can be circulated through the reactor.

I also mentioned that the Yankee plant would be increased from 110,000 to 134,000 kilowatts and that will be done by the installation of a more efficient core in the same reactor.

Mr. RILEY. That clears it up. I did not understand whether or not you would add other cores to it. I believe your overall request, as I understand, is $2,843,900. Is that for operation and construction?

Mr. MCCARTHY. Mr. Riley, that is correct. That includes obligations for our operations as well as obligations for the new construction program for 1960 and portions of our previously authorized construction programs which have not been funded.

Mr. RILEY. On page 14 of your statement, you mentioned the fact that over half of your total estimated operating cost for reactors was for the defense program.

Mr. MCCONE. That is correct.

EXTENT OF DEFENSE EFFORT

Mr. RILEY. Could you tell us what percentage of your overall efforts are for the defense program in the whole operation?

Mr. MCCONE. Our entire operation is about 75 percent defense. Now, this involves the cost of the ore and the refining of it and the operating of plants such as Hanford and Oak Ridge and the development and the manufacture of the weapons and also the development of the reactors for submarines and aircraft and so forth. It would be above 75 percent.

ATOMIC AIRCRAFT

Mr. RILEY. What progress are you making on a light reactor which can be used in airplanes?

Mr. MCCONE. I mentioned in the paper this presents a very extremely difficult problem to us because of the high temperatures that are necessary.

Whether those two problems can be answered or not, I cannot tell you. We are hopeful and the scientists who are working on it feel very optimistic but thew have quite a ways to go.

Mr. RILEY. Thank you.

COMMUNITY DISPOSALS

Now, you mentioned the progress you are making in the sale of the Richland community and Oak Ridge community. Do you have any figures you can give us on the percentage of the return on the Government investment that you are recovering?

Mr. MCCONE. I haven't.

Mr. BLOCH. I think I have it, sir. At Richland we have recovered about $26 million from sales through March.

Mr. RILEY. What percentage of the investment would that be? I am not talking about the operation, but the Government city only.

Mr. BLOCH. The investment, the book value of the properties that are up for sale, these are the housing units or commercial properties, is $34½ million. Through March about $26 million had been recovered.

Mr. RILEY. Is that depreciated value?

Mr. BLOCH. That was the depreciated value, yes, sir. Most of these were built during the war or immediately after the war.

Mr. RILEY. Do you have an appraisal of that?

Mr. BLOCH. Yes. The FHA made the appraisal. The appraised value was $49 million.

Mr. TABER. If the gentleman will yield there, as I understand it that does not include the streets and the utilities?

Mr. BLOCH. No, sir. This is the FHA appraised value of the commercial and other properties, including the vale of the improved lots.

Mr. TABER. But not the utilities and that sort of thing that were put in the streets?

Mr. BLOCH. That is correct, sir.

Mr. RILEY. Is the town supposed to pay for the utilities after it has become incorporated?

Mr. BLOCH. No, sir. There are two things: Under the community disposal act, the act under which the towns are being disposed of, this

provides a discount below the appraised value of up to 25 percent for a resident who has the priority to purchase. Therefore, the sales value would be quite a bit below the appraised market value.

The Community Disposal Act also provides for our transferring these municipal facilties to the incorporated community without any exchange of funds.

Mr. RILEY. Do you have any figures on Oak Ridge?

Mr. BLOCH. I have figures on Oak Ridge, yes.

Mr. RILEY. As fas as I am concerned, you can put it in the record.

Mr. BLOCH. Oak Ridge runs about the same, generally. We have actually recovered $20 million at Oak Ridge through sales. I think the appraised value was on the order of $32 million.

Mr. RILEY. Thank you.

Mr. CANNON. Will you put it in the record.

(The information follows:)

Summary of disposal of Oak Ridge commercial and industrial property

	Millions
Depreciated book value (as of May 31, 1959)	$36.2
Appraised value	32.0
Estimated total value to be received from sales	25.0
Total value received from sales through March 1959	19.9

The CHAIRMAN. Mr. Boland?

YANKEE ATOMIC ELECTRIC CO.

Mr. BOLAND. With reference to the Yankee Atomic Electric Co., you indicated that AEC has granted the Yankee $5 million for research and development.

What is the total cost of the program to Yankee, exclusive of the $5 million? What is the plant going to cost?

Mr. MCCONE. About $55 million, as I remember.

Mr. BOLAND. That is a considerable increase over the original proposition as I recall.

Mr. MCCONE. Somewhat, yes.

Mr. BOLAND. There is a waiver of fuel use here, is that not right?

Mr. MCCONE. That is correct.

Mr. BOLAND. What does that mean to them in matters of dollars?

Mr. MCCONE. About $3 million.

Mr. BOLAND. So actually, you are granting them $8 million instead of $5 million. I have seen the plant. They seem to be getting along pretty well.

NUCLEAR-PROPELLED AIRCRAFT

I take it, Mr. Chairman, with reference to Mr. Riley's questioning on the nuclear-propelled aircraft you are not interested in a crash program. You think you ought to go along slowly?

Mr. MCCONE. That's correct.

Mr. BOLAND. That is at variance with some people who think that this ought to be a crash program. I have seen the plant and I was interested in your reply to Mr. Riley's question with reference to shielding.

From what I have seen of it, it appears to me that the reactor has to be shielded, the crew has to be shielded. You may even have to

shield the field when you get the plane down. We have spent in the neighborhood of close to $1 billion so far in this program.

Mr. McCone. $900 million.

Mr. Boland. There is no question of the shielding problem, is there? Is it possible to develop any shielding material that will stop the penetration of the radiation?

Mr. McCone. Of course, you have materials that will stop—that will shield from radiation at various thicknesses, depending on what they are. This is an area of research that has been carried on now ever since the program was started during the war.

Mr. Boland. Do you think it is too important whether or not Russia gets one up there first? Do you have any knowledge of whether or not they have actually put a nuclear-propelled airplane into action?

Mr. McCone. There has been a good deal of speculation and you are familiar with the press reports and reports that have come out in aviation magazines and so forth from time to time.

Mr. Boland. Does the Air Force?

Mr. McCone. I have no doubt, however, that they are working in this field and from what they have done in other areas, they might make very substantial progress.

Mr. Boland. So far as I am concerned, I am not too concerned whether or not they get it up there first. They can get it up there first if they want because when you get it up there, what good is it?

Mr. McCone. That is a question that the military, the Department of Defense should answer. At the moment I do not think they have defined a military requirement or a weapon system in which this nuclear-powered plane would be used.

Mr. Boland. Should this be a question that should be answered and determined first, "What is the military requirement for it"?

Mr. McCone. I don't know that you can expect the military to answer that question because several years are going to be consumed in flying this plane and testing it out and we are in a period where there is a very rapid development and evolution in our whole weapon systems and I think it would be a little hard for them to pinpoint a specific need. I think about the best you can say, the best that they can say, is that there is a probability that if this was successful, a military requirement would be indicated, but I do not think they can tell you right now what it is.

Mr. Boland. It is going to be a slow, lumbering vehicle and you are building something that will knock it down in a second. My only problem is that I get concerned about the expenditure of money in this kind of program. I can understand our desire to go ahead with it. I can understand the AEC's desire and the military, but I cannot understand the desire to go ahead on a crash basis because this is a program on which we can spend millions and waste the millions. I wonder why we have to increase the amount this year from $65 million to $68.6 million.

Mr. McCone. This was to conform to agreed approach between the Department of Defense and the AEC. The AEC problem is the development of the reactor. The development of the plane and the development of the turbojet and the adaption of the reactor to the plane is the Department of Defense.

Mr. BOLAND. Do you know what the Department of Defense Budget is in this field?

Mr. MCCONE. I think in the total ANP program we each carried about $75 million.

Mr. BOLAND. They only have about $75 million budgeted for their end of the program.

Mr. MCCONE. We each carried $75 million.

Mr. BOLAND. How much will be needed for continuing research on shielding and high-temperature metals? How much will be necessary for this purpose?

Mr. MCCONE. I cannot answer that offhand. At the level that it is being funded now, it is $75 million. There is both research and a considerable amount of hardware going on.

Mr. BOLAND. I note that your justification says that the 1960 estimate provides for the continuation of the program at essentially the 1959 level. I want to commend the Commission for bringing in that request and continuing with that kind of level. Thank you.

URANIUM OXIDE REQUIREMENTS

Mr. MAGNUSON. Mr. McCone, I got the impression when Mr. Cannon was questioning you that the AEC has stuck pat on the uranium oxide purchases sort of against its will; is that true?

Mr. MCCONE. Yes. We would be very much happier if we were taking from the mills 33,000 tons of uranium oxide per year instead of 35,900 tons because 35,900 tons is in excess of our requirements.

Mr. MAGNUSON. How much does it cost?

Mr. MCCONE. It costs about $16,000 a ton or a little more, so we are talking about maybe $50 or $60 million of expenditures for uranium oxide this year in excess of our requirements. Now this is a temporary situation.

Mr. MAGNUSON. How temporary is it? If you have certain commitments how long range are they?

Mr. MCCONE. They last into calendar year 1962. From 1962 on for the next several years our actual contractual commitments are very much less than our requirements. We have several option positions, particularly from foreign suppliers, but those options do not have to be considered until the spring of 1961.

Mr. MAGNUSON. You will be almost completely flexible by that time?

Mr. MCCONE. That is correct. This is a temporary situation, Mr. Magnuson.

Mr. MAGNUSON. How long have you been required by your commitment to purchase more than you need?

Mr. MCCONE. This has built up gradually and I think this year, fiscal 1960, is the first year where we have this excess. In fiscal 1959 we had a slight excess but not great. I think 1961 will be slightly less than 1960 and 1962 falls off and then it drops off quite rapidly.

Mr. MAGNUSON. You said, I believe, there is no appreciable deterioration?

Mr. MCCONE. That is right.

Mr. MAGNUSON. Is there some deterioration?

Mr. MCCONE. No, there is no deterioration.

COMMUNITY DISPOSALS

Mr. MAGNUSON. With respect to the community disposal program of these former government towns, I am particularly interested in the Richland area. Are the folks out there satisfied with the program and the price they have had to pay and so forth?

Mr. MCCONE. Mr. Bloch, maybe you could answer that question. I have been out there two or three times in the last year. I have had no particular complaints. Have you, Mr. Bloch?

Mr. BLOCH. No, sir. So far as I konw everyone is well satisfied. Most of the housing has been sold. As you know, the town is incorporated. They have elected their officials and recently we turned over the fire and police protection and one or two other activities to the new town government.

Mr. MAGNUSON. The fire and police protection has been remarkably efficient under government operation, have they not?

Mr. BLOCH. They have been very good, yes.

Mr. MAGNUSON. I recall when I was a newspaperman doing a story on the Richland traffic record, which was almost unbelievable from the safety standpoint.

Mr. BLOCH. Well, we think that the city will continue these standards.

Mr. MAGNUSON. I hope they do.

Mr. BLOCH. They are responsible people and interested in these sort of things just as we have been.

Mr. MAGNUSON. What is holding up the transfer of the utilities? You said it had not been done yet.

Mr. BLOCH. There is no particular holdup, sir. It is just a question of turning these things over as the new town can get staffed up and becomes ready to take them. We are prepared to turn them over whenever they are ready to accept them.

Mr. FOGARTY. Off the record.

(Discussion off the record.)

Mr. FOGARTY (presiding). Mr. Jensen?

COOPERATION WITH PRIVATE UTILITIES

Mr. JENSEN. Mr. McCone, I feel quite encouraged by the fact that because of the cooperation between the Atomic Energy Commission and private utilities, atomic power has been brought down to almost a competitive rate with hydro power. There are an awful lot of people who think hydro power is cheap power. Any hydro powerplant that is built today, private engineers and Federal engineers will tell you that power from hydroelectric plants recently built cannot, with few exceptions, be sold for less than 7½ mills per kilowatt, so if, as I understand it, atomic power is now being produced by the Northern Pacific Gas Co. for around 9 mills, they are getting pretty close to the cost of conventional power.

Now hydro power, of course, is available even at 7½ mills as peaking power, but it is necessary to have steam power to firm that hydropower in order to dispose of it at a price that the people can afford to pay.

Now, of course, we have the great Columbia River which is the greatest power-producing river in America. It produces power at considerably less than plants on many other rivers do. But even today, a plant built on the Columbia River would have to sell for possibly 4

or 5 mills per kilowatt-hour in order to pay off according to law in a reasonable length of time.

That is a thing that too many people do not realize. Now the reason why there has not been more money invested by private industry in atomic energy plants for civilian power is because of the fact that it was only in 1957 that Congress passed the law which provided that the Government would stand $500 million damage on any single accident that might occur because of an atomic explosion in the plant and the private utilities agreed to stand somewhere between $65 and $100 million before the Government took over and guaranteed their $500 million.

Since then, we have had more interest in private industries risk capital than we had before that time. Is that not a fact, Mr. McCone?

Mr. McCone. Yes. I think the Government indemnification at the upper level has had considerable effect on the interest of private utilities.

REACTOR CONCEPTS UNDER ACTIVE CONSIDERATION

Mr. Jensen. Now I would like for whoever is competent to discuss it, to describe briefly each of the different principles of reactor concepts which are under active consideration at this time.

Mr. McCone. I think that can best be answered by Dr. Pittman, who is Director of our Reactor Development Division.

Mr. Jensen. All right, Doctor. You can explain it briefly now and then expand it for the record.

Dr. Pittman. I can go down the list of the reactors that are under construction by private industrial groups, either with their own funds alone, or on a cooperative arrangement, with the Atomic Energy Commission.

Mr. Jensen. I think I will just have you supply it for the record.

Dr. Pittman. All right.

Mr. Jensen. And I would like to have you supply for the record in some detail the status of each concept with regard to whether basic research is continuing, whether a prototype or large-scale plant has been or is being constructed or is planned and what economic results are expected. Also, what chemical, metallurical or operational problems are yet to be solved.

Also, and finally, what concepts now give the greatest promise and competitive and economic power and at what cost per kilowatt-hour, including all fixed and operating cost, under Federal and under private financing costs.

I will hand you this so that you can have it.

Dr. Pittman. Thank you.

(The information referred to follows:)

DESCRIPTION AND STATUS OF ADVANCEMENT OF TECHNOLOGY OF VARIOUS NUCLEAR REACTOR SYSTEMS FOR POWER PLANT PURPOSES

There are eight (8) basic types of nuclear reactor systems which are under active consideration at this time in the development of economic nuclear power plant systems. A description of each of these reactor types are as follows:

DESCRIPTION—REACTOR TYPE

A. Water cooled

Pressurized water.—Fission heat is removed from the reactor core by water pressurized at about 2,000 pounds per square inch to keep it from boiling. Steam is generated in a heat exchanger through which the pressurized water passes.

Boiling water.—Water boils in the reactor core forming saturated steam which flows directly to a turbine.

Heavy water.—Heavy water (D_2O) serves as reflector and moderator, pressurized or unpressurized. Coolant may be pressurized, heavy water, light water, or other liquid. Heavy water makes possible the use of normal or slightly enriched fuel allowing for reductions in fuel cycle costs.

B. Organic cooled

Involves the use of organic fluids for cooling and possibly for moderating, reflecting, and shielding nuclear reactors. Heat is removed from the core by organic coolant at low or moderate pressure. Steam is generated in boiler or heat exchanger.

C. Sodium cooled

Sodium graphite.—Sodium takes high temperature heat from core to intermediate heat exchanger.

Fast breeder.—Heat from fission by fast neutrons is transferred by sodium coolant through intermediate cycle to boilers as in sodium graphite type. Neutrons escaping from core into blanket breed fissionable plutonium 239 from fertile uranium 238.

D. Gas cooled

High temperature heat from reactor is carried by a gas to a heat exchanger where steam is generated. The gas returns to the reactor in a closed cycle.

E. Fluid fuels

Uses solution or suspension of fuel in fluid carrier medium. The fuel solution or suspension is pumped into the reactor vessel where it generates heat and then through a heat exchanger where it gives up its heat to make steam.

STATUS OF DEVELOPMENT

Water cooled reactors

Heterogeneous reactors which are moderated and cooled with light water are particularly suitable for meeting short-range program objectives and have promise for meeting the long-range program objectives. They are suitable for small plants as well as large plants, although pressure vessel size limitations may become important in very large sizes.

The major portion of power reactor technology developed and demonstrated to date in the United States is based on water reactor systems. Feasibility and reliability have been demonstrated by those reactors now built and in operation. All the water reactors now in operation produce saturated steam. The use of saturated steam requires larger and more expensive equipment in the nonnuclear portion of the plant than is now used in superheated steam, fossil-fueled plants. The large volume flow, erosion and corrosion problems introduced by high moisture content, and lack of production volume, all contribute to the relatively high cost of the nonnuclear portion of a saturated steam nuclear plant.

Although technology in water reactors is further advanced than in other reactor concepts, projections of economic potential are still subject to a number of uncertainties. These include uncertainties in fuel cycle behavior and large plant performance. For these reasons it is necessary at least for the present to continue extensive effort on at least one or two other reactor types to meet the objective of competitive power at the earliest date and to provide competitive incentives as well as to provide insurance in case some of the expected developments in the water reactor concept do not materialize.

The major metallurgical obstacles to economic nuclear power utilizing water-cooled reactors are successfully developed fuel elements. Some of the problems of UO_2 fuel elements, which are planned for almost every major water-cooled power reactor, are—

1. Lack of knowledge of maximum allowable power density.
2. Lack of knowledge of fission gas release as a function of burnup density, temperature, and time.
3. Determination of the effect of cladding failure or system performance.
4. Development of corrosion-resistant aluminum alloys.
5. Lack of knowledge or long-term burnup effects on fuel elements.

Research and development efforts to solve these problems are continuing.

Pressurized water.—The pressurized water reactors have reached a more advanced state of development than any other reactor type due primarily to the extensive research and development work carried out in the development of nuclear-powered propulsion plants for the Navy. The research and development work plus the operating experience in propulsion plants and land-based prototypes has culminated in the design and construction of the Shippingport plant. Based on this technology the Yankee Atomic Electric Co. and the Consolidated Edison Co. are in advanced stages of construction of central station plants utilizing pressurized water reactors.

The pressurized water reactor differs from the boiling water reactor in that bulk boiling and steam generation in the core is prevented by the pressure maintained in the system. Thus, a pressurized water reactor has a primary loop which transmits reactor heat across a heat exchanger to the nonradioactive secondary side of the system where the saturated steam is formed for driving the turbine. Demonstrated stability and load-following characteristics of large reactors and absence of radioactivity in the steam system are important assets of pressurized water reactors.

During fiscal year 1960 much new information on pressurized water reactors will become available from reactors of this type now operating or under construction. The principal area for improvement in these reactor systems appears to be the development of improved, lower cost fuel elements. It appears that improvement now being considered can be tested by installation of new cores or other experimental operation of plants already planned.

Boiling water.—The essential feature of a boiling water reactor is the production of steam in the reactor core. It is thus possible to reduce the pressure of the system and, in the case of a direct cycle boiling reactor, to eliminate secondary equipment for steam generation. The reduced costs expected from these features must be evaluated against factors such as handling radioactive steam and load response characteristics. The satisfactory results of research and development, the potential indicated by advance design, the excellent operating experience obtained on such small boiling water reactor plants as the Borax experiment, EBWR, and VBWR, and the design and construction experience on the large Dresden plant provide a major basis for the current optimism with respect to the probability that nuclear powerplants can be competitive with fossil-fuel plants in significant areas of the United States within 10 years.

Heavy water.—The use of heavy water, an efficient moderator, in power reactors is attractive principally because it permits utilization of natural uranium as fuel without dependence on enriched uranium. The Commission in 1956 undertook additional research and development and analysis of design studies to provide a basis for proceeding with a large-scale reactor of this type. Preliminary study indicated that construction of a large plant was feasible. This has resulted in a preliminary design for a heavy water components test reactor (HWCTR), a facility for test irradiation of full-size natural uranium fuel elements and other components under power reactor operating conditions.

The HWCTR is a 60 MWT pressure vessel type reactor, cooled and moderated with heavy water and is being designed as a versatile experimental reactor to test and evaluate fuels, systems, and components being considered and developed for use in large-scale heavy water moderated power reactors. There are provisions for six separate test loops so that various coolants and associated fuel elements may be evaluated simultaneously. The facility will be used to test a number of uranium metallic and ceramic fuel elements to determine and minimize heavy water leakage to evaluate heavy water purification components, to determine means for handling tritium produced by irradiation of deuterium, to test component connecting seals, to evaluate heavy water heat exchanger design, and to determine the adequacy of developed instrumentation for detection of fuel element behavior and failures.

The Commission is working toward a more extensive cooperative program with the Canadians which will help advance the development of heavy water moderated reactors operating on natural uranium. A formal program for maintaining close cooperation in the development of heavy water moderated power reactors has been in existence with the Canadians for about 2 years. This program has provided for exchange of information, and technical personnel and for the use of irradiation facilities.

The special interest of other countries in reactors which will operate on natural uranium is recognized not only in cooperation with the Canadians but also in

participation of representatives of other groups in the present program of the United States. For example, the design study currently in progress on heavy water moderated reactors operable on natural uranium includes participation by representatives of Sweden, OEEC, and Euratom.

Organic cooled reactors

Organic materials are of interest for use as moderator and coolant or as a coolant in combination with some other moderator such as graphite or heavy water. Reactors using organic fluids as both moderator and coolant have a range of applicability comparable to that of water reactors. There is perhaps somewhat less serious limitation on large size for reactors using organic materials in place of water because of the lower pressure of the primary system for given steam conditions. The chemical compatibility of organic with fuel and structural materials and the nonradioactive nature of the primary system offer promise of lower construction costs. This must be balanced against the cost of makeup for loss or decomposition of the organic material. Only by actual operation experience can this balance be truly evaluated. At this time estimated costs from large-scale organic-cooled reactors are in strong competition with those from other systems which are under intensive development.

Use of the organic as only a coolant rather than as coolant and moderator reduces the cost of makeup and retains the advantages of chemical compatibility and low pressure in the primary system. Development of organic coolant technology could have important byproduct value for systems in which low shielding weight and absence of radioactivity from the primary system are of special significance.

The low thermal conductivity of organic materials relative to water does not appear to be a serious handicap at the present time, since limitations imposed by the low thermal conductivity of oxide fuels are preventing use of the full potential of water as coolant. In order to achieve higher steam efficiencies, however, aluminum claddings must be developed which will retain structural strength above at temperatures higher than the present limit of 550° F.

Sodium-cooled reactors

The unique contribution of sodium-cooled thermal reactor systems is high thermal efficiency coupled with very low primary system pressure. With proper fuel development the use of sodium as a coolant can also lead to higher specific power than any other type of coolant. Radiation from the sodium requires heavy shielding of the primary coolant system and introduces some difficulty in connection with plant maintenance. However, it may actually develop that this radiation will have value as a byproduct.

The principal area of development of sodium-cooled thermal reactors uses graphite as the moderator. However, sodium may also be used in connection with other moderators such as beryllium, beryllium oxide, or heavy water. Graphite-moderated systems, in particular, are expected to have favorable economics only in large sizes. The high temperature and other characteristics associated with sodium-cooled systems introduce new fuel element development problems. Problems, such as the development of fuel claddings above 1,200° F., the temperature limit of stainless steel in sodium systems, and the development of fuels which will be stable in irradiation fields for long times and at the same time possess good thermal characteristics to take full advantage of the heat transfer properties of the sodium coolant. Assuming these problems can be solved, either uranium or thorium fuel cycles can be used. While breeding is not possible in sodium graphite reactors, use of an intermediate spectrum with thorium fuels may lead to high conversion ratios.

Components in the sodium-coolant system are of direct application to fast breeder reactor systems now under development and continued development of these components can be justified under either program.

Sodium-cooled thermal reactors or those operating in the intermediate neutron energy range are not considered as capable of achieving competitive power costs as soon as they may be achieved by other reactor concepts in the program. However, in the very large sizes which can be developed for the future they are expected to have a definite economic advantage over those systems which may first achieve economic power.

Fast breeder.—The unique contribution of reactors operating on fast neutrons is one of breeding on the plutonium-uranium fuel cycle. The development of reactors which can utilize both fissionable and fertile materials is essential to the long-range program. The successful achievement of economic breeders will

greatly increase the amount of energy available from nuclear fission to supply continued expansion in the energy demands of the world. The development of fast breeder power reactors is one of the major long-range objectives in the power reactor development program of the United States.

Utilization of both fissionable and fertile isotopes of uranium in fast reactors is possible because of the following factors (*a*) approximately 15 percent of the energy produced can be obtained by the direct fissioning of U^{238}; (*b*) neutron economy is high because reactor materials of construction have low neutron capture cross sections in the fast neutron spectrum relative to fuels; and (*c*) plutonium's nuclear characteristics are favorable for use as a fuel in fast reactors.

The achievement of reasonable doubling times with fast power breeders depend upon solving many engineering problems associated with achieving a very high specific power in a fast reactor. In addition, the inherently large amount of fuel required in a fast reactor, the fuel cycle problems of cheaper fabrication, easier reprocessing and longer burnup, are more acute.

The Commission's fast breeder power reactor development program includes many activities on fuel cycle research, reactor safety studies, and reactor design, construction, and operation. The reactor safety work includes an investigation of the meltdown characteristics of fast reactor fuel in the transient reactor test facility (treat).

Gas-cooled reactors

Gas-cooled reactors offer immediate promise of providing steam conditions consistent with modern practices of the utility industry at fuel costs which may be lower than achievable with water-cooled systems. Gas-cooled reactors offer development potential to provide very high temperature coolant which may be of interest in connection with operation of closed cycle gas turbines, or ultimately for application to high temperature industrial processes.

The low specific power and consequent high capital cost of gas-cooled reactors considered technically feasible until recently made gas look relatively unattractive as a power reactor coolant under economic conditions of the United States. Through programs carried out in our own laboratories in both the civilian and military reactor fields, through our cooperative efforts with the British in gas-cooled reactor technology, and through work done by American industry, the way has been pointed toward the possibility of achieving higher specific powers and of realizing capital costs comparable with those of other reactors now under development. Because of the promise now offered by gas-cooled reactor systems, the United States has embarked upon an extensive program for the development of advanced gas-cooled reactor technology. The gas-cooled reactor fuel elements, because of the low conductivity of gas coolants require development of extended surface fuel elements with a minimum amount of obstruction to coolant flow.

Fluid fuels reactors

The fluid-fuel reactors development program includes the development of aqueous homogeneous reactors, fused-salt reactor, and liquid metal-fueled reactors. There are three features or potential characteristics common to all fluid-fuel reactor systems that are of particular interest. These are (*a*) elimination of fuel fabrication, (*b*) long equivalent fuel irradiation cycle, and (*c*) high specific power. In addition systems using heavy water offer promise of high neutron economy, and the liquid metal and fused salt systems offer potential of high thermal efficiency with low system pressure. The combination of high specific power and high neutron economy leads to the interest in aqueous homogeneous reactors as perhaps the only real possibility of breeding on the U^{233} thorium fuel cycle with a reasonable doubling time.

Recent experience with the homogeneous reactor experiment No. 2 (HRE–2) has been somewhat discouraging in that instability of the fuel solution, probably brought about by overheating of localized stagnant regions in the reactor core, has led to failure of the reactor zircaloy core tank and to fluctuations in reactor power level during operation.

In December of 1958, the Westinghouse Electric Corp. and the Pennsylvania Power & Light Co. withdrew their proposal to develop and construct a 150-megawatt (E), aqueous, single-region slurry reactor (PAR). This decision was brought about by the combined uncertainties in technical feasibility existing in several areas of the plant design, and the high investment risk associated with proceeding immediately to full-scale plant construction.

Despite these temporary setbacks in the aqueous program the prospects of achieving low nuclear power cost and thermal breeding with fluid-fuel reactors through long-range development effort still looks promising.

The Commission has undertaken a major reevaluation of the existing fluid-fuel reactor programs. Research and development directed primarily toward basic problems in chemistry and metallurgy will continue during fiscal year 1960, at a rate adequate to meet present needs consisting with technological uncertainties. Operation of the HRE–2 will continue during at least part of fiscal year 1960 in order to gain improved understanding of fuel solution behavior and additional operating experience on reliability of components and experience in maintaining radioactive systems.

Tabulation—Nuclear reactors built, building, or planned in the United States as of June 30, 1959, suitable for power production

PROTOTYPE POWER REACTORS

Name and/or owner	Location	Type	Power (kilowatts)		Estimated power cost mills/ kilowatt-hour [1]
			Electrical (net)	Thermal	
Operable:					
Shippingport Atomic Power Station	Shippingport, Pa	Pressurized water	60,000	231,000	80
Vallecitos boiling water	Pleasanton, Calif	Boiling water	5,000	20,000	[2]
Being built:					
Dresden Nuclear Power Station	Morris, Ill	do	180,000	626,000	[2]
Consolidated Edison thorium reactor	Indian Point, N.Y	Pressurized water	255,000	500,000	[2]
Enrico Fermi atomic powerplant	Lagoona Beach, Mich	Fast breeder	90,000	300,000	23
Yankee Atomic Electric Co	Rowe, Mass	Pressurized water	110,000	392,000	20
Rural Cooperative Power Association	Elk River, Minn	Boiling water	22,000	73,000	20
City of Piqua, Ohio	Piqua, Ohio	Organic moderated	11,400	45,500	26
Hallam nuclear power facility	Hallam, Nebr	Sodium graphite	75,000	245,000	17
Northern States Power Co	Sioux Falls, S. Dak	Boiling water	62,000	203,000	13
Carolinas-Virginia Nuclear Power Association	Parr Shoals, S.C	Pressurized heavy water	16,950	60,500	33
East Central and Florida West Coast Nuclear Power Groups.	Not announced	Gas-cooled, heavy water moderated	46,000	173,000	12
Pacific Gas & Electric Co	Humboldt, Calif	Boiling water	50,000	164,000	[2]
Planned:					
Philadelphia Electric Co	York County, Pa	Gas-cooled, graphite, moderated	40,000	115,000	15
Prototype-advanced boiling water	Not yet determined	Boiling water	50,000–100,000		14
Prototype (small nuclear powerplant)	do	Not determined	20,000		16
Prototype-advance design utilizing superheat	do	Boiling water	15,000	50,000	[3]

See footnotes at end of table, p. 106.

Tabulation—Nuclear reactors built, building, or planned in the United States as of June 30, 1959, suitable for power production—Continued

POWER REACTOR EXPERIMENTS

Name and/or owner	Location	Type	Power (kilowatts)		Estimated power cost mills/kilowatt-hour [1]
			Electrical (net)	Thermal	
Operated, later dismantled:					
Boiling reactor experiment Nos. 1-4	NRTS, Idaho	Boiling water	(4)	1,400	
Homogeneous reactor experiment, No. 1	Oak Ridge, Tenn	Aqueous homogeneous	140	1,000	
Los Alamos power reactor experiment, No. 1	Los Alamos, N. Mex	do	(4)	2,000	
Operable:					
Experimental breeder No. 1 (ERB-1)	NRTS, Idaho	Fast breeder	150	1,400	
Experimental boiling water (EBWR)	Lemont, Ill	Boiling water	4,500	20,000	
Sodium reactor (SRE)	Santa Susanna, Calif	Sodium-graphite	6,000	20,000	
Organic moderated (OMRE)	NRTS, Idaho	Organic-moderated	(5)	5,000-15,000	
Homogeneous reactor No. 2 (HRE-2)	Oak Ridge, Tenn	Aqueous homogeneous	(5)	5,220	
Being built:					
Experimental breeder No. 2 (EBR-2)	NRTS, Idaho	Fast breeder	16,500	62,500	39
Heavy water component test (HWCTR)	Savannah River	Heavy water	(4)	61,000	
Plutonium recycle test (PRTR)	Hanford	Plutonium recycle	(4)	70,000	
Flexible experimental gas-cooled (FEGCR)	Oak Ridge, Tenn	Gas-cooled, graphite, moderated	26,000	84,000	34
Planned:					
Experimental organic-cooled reactor (EOCR)	NRTS, Idaho	Organic moderated	(4)		
Advanced sodium reactor experiment (SRE-2)	Santa Susanna, Calif	Sodium- graphite	(4)		
Experimental low-temperature process heat	Not yet determined	Pressurized water	(4)	40,000	

[1] Except for Shippingport, calculated at 14 percent fixed charges and 80 percent load factor. Shippingport based on estimated load factor of 53 percent for fiscal year 1959.
[2] Private.
[3] Not yet available.
[4] No electricity.
[5] Negligible.

FUTURE POTENTIAL

It is not possible to name any one concept or concepts as having the greatest promise for competitive economic power at the present state of development. The reactor concepts which show the greatest promise for low-cost power are the furtherest from practical development. Until many more years of research and development have been expanded, exact costs cannot be predicted. The solution to unforeseen problems may increase the cost of power from these reactors above the cost of power from ones which are presently at a more advanced state of development.

The Division of Reactor Development is presently preparing a 10-year plan directed toward achieving the objectives of the civilian nuclear reactor program. In preparing this plan, an attempt is being made to determine the potential of each concept presently under development and the research and development program required to evolve a practical power reactor system. It is expected that this report will be completed early next year.

At the present time the pressurized water, boiling water and to a lesser extent the organic and heavy water natural uranium fueled reactors are sufficiently developed to accurately estimate power costs. This was done in the course of the design studies for 300 MWE plants and was reported to Congress on May 1, 1959. The studies showed that in this size range and under certain prescribed economic circumstances all except the heavy water systems could produce power from 8 to 9 mills per kilowatt-hour. The heavy water systems' power costs were approximately 1 to 2 mills per kilowatt-hour higher.

Similar detailed design studies have not been made for other or smaller plants, but it is expected that the relative rating would remain unchanged. The 10-year program will attempt to define the potential of all concepts more clearly, and will provide more specific guidance to the civilian reactor program.

FELLOWSHIP PROGRAM

Mr. JENSEN. Now, I think the most important questions have been asked and answered or will be answered for the record. I was quite interested in your fellowship program. What is the cost of that program?

What is the cost in this fiscal year and what are you asking for in fiscal 1960?

Mr. MCCONE. Dr. Dunham, do you have those costs?

General LUEDECKE. The total cost for the education and training program for 1959 and $13.7 million. The request in 1960 is for $14.8 million, an increase of——

Mr. JENSEN. Where do you propose to expend that difference over and above what you got this year?

Mr. MCCARTHY. The budget, Mr. Jensen, for the operation of schools, which includes the international school at Argonne which trains both foreign and domestic students, and for the other schools which we will operate, is $2.136 million for 1960 as compared to $1.584 million in 1959. The fellowship program in 1960 is estimated to cost $1.210 million as opposed to $854,000 in 1959.

Mr. JENSEN. How many fellowships were issued?

Mr. MCCARTHY. The total fellowships in 1960 will amount to 1,210 fellows.

Mr. JENSEN. How much did they receive on an average fellowship?

Mr. MCCARTHY. I am sorry. That was the total in school and also the fellowships. The fellowships themselves will be 377 in 1960 as opposed to 303 in 1959. They break down into the nuclear science and engineering fellows, 150 in 1960 as opposed to 115 in 1959.

That is in the reactor development nuclear engineering fellowships. Radiological physics——

Mr. JENSEN. Let me ask you this; have you any definite conclusive proof that these fellowships are worth the money that we are spending or has your program been in operation long enough to make such a determination?

Dr. PITTMAN. Since the program is only 2 years old, I would like to supply you the number of students that have been helped. This information is derived from a followup study of the first group of fellows accepted under the program.

Mr. JENSEN. You can supply it for the record.

(The information referred to follows:)

VALUE OF AEC FELLOWSHIP IN NUCLEAR SCIENCE AND ENGINEERING

On March 5, 1959, the ORINS Fellowship Board stated "In the opinion of the Board, the value of the fellowship program is confirmed by the large portion of AEC fellows who have accepted employment in organizations which are making direct contributions to the U.S. atomic energy program and by the high caliber of work performed by these men in their postgraduate employment. The Board also takes satisfaction in noting that a substantial portion of former fellows are continuing graduate study at an advanced level. The acquaintanceship with nuclear engineering which these men secured during their fellowship programs is bound to contribute to their future professional growth and will have a beneficial effect on the professional fields with which they become associated." The statistics developed by the followup study are: of 59 fellows who finished their fellowship in September 1958, 29 are continuing in universities, 3 accepted employment with the AEC, 4 accepted appointments as university faculty, 5 accepted employment at AEC national laboratories, and 18 accepted employment with companies having active nuclear energy programs.

To date, 199 students have attended universities under this fellowship program. Since the program has only been effective 2 years, data is not yet available regarding 130 of these individuals regarding employment.

Mr. JENSEN. I want you to understand that I favor the program but I think that it is right and proper that we should have a full explanation of the program and your estimation of the value of it to the United States.

Now, you had some more figures.

Mr. MCCARTHY. I wanted to complete the type of fellowships.

The radiological physics, in 1960 there will be 199 fellows receiving fellowships as opposed to 166 in 1959. The industrial hygiene, which is Dr. Dunham's specialized program, there will be nine in 1960 as compared to eight in 1959, the current year.

Industrial medicine, there will be 14 in 1960 and also 14 in 1959.

In 1960 there is a new program planned for radiological physics advanced graduate studies where there will be five as opposed to none in 1959.

Mr. JENSEN. These fellowships are scattered quite universally at different universities and colleges.

Mr. MCCARTHY. Yes. I think in all cases they are eligible to pick their own school.

Dr. DUNHAM. The selection of fellows is made by a special fellowship committee for attendance at certain approved institutions. So they can't just get a fellowship and go anywhere.

Mr. JENSEN. There are some universities and colleges that put greater emphasis on this type of scientific instruction.

Dr. DUNHAM. That is correct.

Mr. JENSEN. Do you have anything else?

Mr. MCCARTHY. That is all I have.

DEVELOPMENT OF STUDENT INTERESTS IN SCIENCE

Mr. JENSEN. If you will remember, I think it was when I was first on this committee, 4 years ago at least, when I made the remark that according to the newspapers Russia was ahead of us in the instruction in schools in all the sciences, and I asked the Commission what they were doing about it.

The answer was that they had not done anything about it. They did not know there was anything they could do about it. I suggested that the Atomic Energy Commission write a letter to the president of every college or the board of every college and university, urging them to make a talk at the first day in college urging the students to take more interest in the sciences.

They agreed to do that and they did, as some of you gentlemen know. I was told a couple of years afterward that it did bring good results. It brought up considerably the percentage of students who majored in the sciences. I am a little bit proud of the fact that that was done.

Our chairman, Mr. Cannon, I think the next year said why just reserve it to the colleges? Why not do the same thing with the high schools? And I think that was done to some extent.

Can anyone here give us the facts as to just what you are doing in that respect now? Are you continuing to write these letters urging that these students major in science? Are you continuing to do that?

Mr. MCCONE. I do not think that we have any regular program of contacting either the high schools or the colleges in the interest of urging registration in the sciences. Now, there is a great deal done individually and visiting with educators and speaking at colleges and in setting forth this whole question of the opportunities in these particular disciplines. But as far as an organized program is concerned, I do not believe that we have such an overall program.

Mr. JENSEN. Well, you are furnishing information to colleges and universities.

Mr. MCCONE. That is correct, a very substantial amount of that.

Mr. JENSEN. Under this program you are also furnishing instruments, are you not?

Mr. MCCONE. That is correct.

Mr. JENSEN. And trying to teach these children the know-how in the nuclear sciences through your pamphlets which are distributed in the colleges?

Mr. MCCONE. That is right.

Mr. JENSEN. So you have followed through to that extent. But your first letters, I think, inspired the heads of the colleges and universities to take a greater interest and to urge that their students take a greater interest in this new development in the field of nuclear science and all other sciences.

1960 BUDGET REQUEST

Now, the total amount of funds which you are requesting this year you have already given, but will you just repeat it again?

Mr. MCCARTHY. The obligation estimated for 1960, Mr. Jensen, are $2,972,616,000. Included in that are $128.7 million worth of plant moneys being carried over for projects that will not be let under contract this year which comes to the net figure which Mr. Riley men-

tioned which is in our statement here in total of $2,843,900,000. That is the new obligation in 1960 and added to that is $128.7 million carried over from 1959 for projects that will not be obligated this year but will be obligated in 1960.

Mr. JENSEN. What did Congress appropriate to AEC for fiscal year 1959?

Mr. MCCARTHY. For 1959 the total appropriation made by the Congress was $2,647,300,000.

Mr. JENSEN. The increase is——

Mr. MCCARTHY. Appropriationwise in 1960 the request is for $2.687 billion for new appropriations. There will be some carryover moneys, which are free, which are applied to the obligation.

Mr. JENSEN. That is a difference of——

Mr. MCCARTHY. On the obligation side it is an increase in total of $290 million if we measure the present programs in terms of obligation compared to 1959.

Mr. JENSEN. Most of that is for what activity?

Mr. MCCARTHY. The big increase, of course, in the operating program will come in the raw materials to take care of the increased raw material requirements, in the reactor development program. These will be the two largest ones.

In the physical research program and in our biology and medicine program there is a small increase.

NUMBER OF EMPLOYEES

Mr. JENSEN. How many people did you have employed on an average in fiscal 1959?

Mr. MCCARTHY. In 1959—we started the year in 1959 with a—let me see. Our beginning employment was 6,865 as a grand total. Our estimated employment at the end of this fiscal year will be 6,800. In other words, we came down by 65 in 1959 from our opening strength.

Mr. JENSEN. What is your request this year?

Mr. MCCARTHY. Our request this year is for 6,921, an increase of 121 employees.

Mr. JENSEN. Where will those extra employees be placed?

Mr. MCCARTHY. The big requirements, of course, in all the inspection programs, inspecting the licensees throughout the country. Another one, of course, is the foreign programs, the Euratom program which is coming into being, personnel who have to be engaged in that program.

Also, of course, the safeguard program for oversea safeguard of our materials. These are three of the biggest ones.

Mr. JENSEN. Off the record.

(Discussion off the record.)

The CHAIRMAN. Dr. Fenton?

Mr. FENTON. I have a few general questions, Mr. Chairman.

TYPES AND USES OF ISOTOPES

I am very much interested in the medical aspects of the AEC. I wonder if anybody can comment on how many isotopes, radioisotopes we now have.

Dr. DUNHAM. You mean that are used in medicine?

Mr. FENTON. Yes.

Dr. DUNHAM. About 8 or 10. I can supply the exact number for the record, but there are about 8 or 10 used commonly in medicine or medical research.

Mr. FENTON. There are other types besides medical?

Dr. DUNHAM. Yes.

Mr. FENTON. How many different types have you?

Dr. DUNHAM. The total number of isotopes is approximately 900.

Mr. FENTON. When I was at Oak Ridge I saw quite a catalog of them.

Dr. DUNHAM. You mean how many are available on the market today?

Mr. FENTON. Yes.

Dr. AEBERSOLD. About 120 varieties are available through the Oak Ridge catalog.

Mr. FENTON. I thought there were more than that.

Dr. AEBERSOLD. That is just as simple elements and compounds. In terms of complex compounds containing isotopes, it is several thousand varieties.

Mr. FENTON. Is there any way of giving us a brief idea, a record of usage of those isotopes?

Dr. AEBERSOLD. In what field? They are used in all fields.

Mr. FENTON. A brief analysis of what they are used for.

Dr. AEBERSOLD. Yes, sir. They are widely used, by about 5,000 different groups in the United States, for research and for practical application in medicine, agriculture and industry. They are used in about 2,500 frontline medical research programs in all phases of national health, for example in studies of cancer, polio, heart disease, arteriosclerosis, virus infections, and so forth. They are used by all 82 medical schools for training and application.

They are used by all the agricultural experiment stations for studying all kinds of plant and animal diseases, for improving crops, and so forth. They are used by 2,000 industrial firms in the United States for research on and improvement of all types of products. For example, thousands of isotope thickness gages are used to measure and control the thickness of hundreds of commercial products.

Isotope gages are used for monitoring and controlling all kinds of sheet and strip products: paper, plastics, floor covering, steel, aluminum, tinplate, sand paper, scotch tape—everything in sheet form, to see that the thickness is uniform, that the material won't tear and that it will give better service to the consumer.

Isotope gages often allow a speeding up of the plant to get 3 or 4 percent more production with the same uniformity. The savings that these gages are estimated to make run into many millions of dollars per year to American industry. The increase in real productivity is most important.

In addition, large sources of gamma radiation are used for radiographing all types of castings and welds. About 500 companies use them for nondestructive testing. That is, you can tell whether the product is uniform throughout or there are defects in it by pictures

taken using the strong penetrating gamma rays. This means that they are not only better products than before but much safer ones.

For example, in pressure vessels it is important that all the welds are radiographed to be sure that the vessel won't blow up or leak. In large pipelines that are laid across the country for hundreds of miles, it is necessary before the pipe is buried that each weld is radiographed.

Mr. FENTON. I believe you gave us some indication of that in your talk the other day, but I thought probably a brief description of some of those things should be in the record.

CANCER RESEARCH

Just how far have we gone, Doctor, in cancer research in cooperating with the Institute of Health?

Dr. DUNHAM. Our cancer research program is a fairly limited one. We spend about $4 million a year in cancer research as such, nearly $2 million at the Argonne Cancer Research Hospital at the University of Chicago, then a good sum is spent at the Brookhaven National Laboratory, at the medical center there, and at Oak Ridge Institute of Nuclear Studies' Medical Center.

We have tried to keep our cancer research program tied to special facilities that are associated with atomic energy. On the other hand, these groups cooperate. Cancer society fellows actually go and take residence at the Oak Ridge Institute of Nuclear Studies or Public Health Service fellows may carry out research at the Argonne Cancer Research Hospital.

So, I think one can say that it is all part of the same effort to get answers to the cancer problem. We do not support much in the way of outside grants to individual investigators for cancer research feeling that that is primarily for the National Cancer Institute.

Our program is largely on site in our larger installations but we try to see that it is a cooperative effort.

Mr. FENTON. Do you cooperate with the Public Health people?

Dr. DUNHAM. Very definitely.

Mr. FENTON. I think that is laudable because we don't want to see any duplication of efforts there, although duplication in this instance would be all right if we got results. From your research in cancer, have you developed anything new?

Mr. DUNHAM. We have not produced any new or dramatic cures. On the other hand, the new cobalt source in the teletherapy unit at Argonne Cancer Research Hospital is a particularly powerful source and seems to be producing very nice results.

Three days ago they treated the first patient at the Argonne Cancer Research Hospital with a 40-Mev. linear accelerator. This is something which is relatively new in approaching the treatment of cancer, this particular energy range, and we have to learn some things about it.

At our University of Rochester project we are studying the immunology of cancer with a view to perhaps developing antibodies against cancer cells and by making those antibodies radioactive one might think in terms of treating cancer.

This experimental work is moving ahead very nicely and they are now able to concentrate to develop antibodies which will concentrate

90 percent in the tumor and very few of them go elsewhere in the body. This, of course, is in experimental animals. I do not believe any experimental tumors have been cured yet, but the dose that becomes available—usually they use radio-iodine as the radioactive isotope—is getting big enough now so that one can think in terms of treating animal cancers.

Whether this is going to work out in humans, I think only time will tell. We are supporting similar work at Buffalo, at the Roswell Park Institute on immunology of cancer and a small project at the University of Michigan. We feel that isotopes have a particular value in studying this particular approach to cancer treatment.

Mr. FENTON. In your research work, have you developed anything new as far as the etiology is concerned?

Dr. DUNHAM. I do not believe directly from research supported by the Atomic Energy Commission. We are learning an awful lot more about how radiation produces cancer but our program would not be likely to turn up new causes of cancer as such, though tracer work with carcinogenec materials is being done.

Most of that is done under the auspices of the National Institute of Health and the Cancer Society.

Mr. FENTON. Thank you, Doctor.

ISOTOPE DEVELOPMENT

In what period of time were all those isotopes isolated, particularly by the Atomic Energy Commission?

Dr. AEBERSOLD. We started in 1946 right after the war was ended. We developed a program even when the Manhattan District was still operating under General Groves to make isotopes available from atomic reactors. As soon as the Commission took over in 1947 the program became a civilian program and has been increasing every year in making larger quantities and greater varieties of isotopes available.

Mr. FENTON. Has industry cooperated with you people?

Dr. AEBERSOLD. Yes, sir. We supply largely the basic reactor irradiation and a large amount of the final services are done by private enterprise. For example, nearly all the radioactive compounds are made by private suppliers, over 100 firms supply isotope services beyond the basic service supplied by the Commission.

For example, all the radioactive drugs used in medicine are made by several pharmaceutical companies starting with radioactive materials that we produce in simple form. They then convert these into the desired radioactive pharmaceuticals according to pharmaceutical standards to meet the specifications of the Federal Food and Drug Act.

Mr. FENTON. Then, in the field of civilian use you have been a considerable help to the country, is that right?

Dr. AEBERSOLD. Yes, sir. We think that isotopes are the major, most dramatic success story of the peaceful uses of atomic energy.

ATOMIC POWERPLANT IN ITALY

Mr. FENTON. Mr. Chairman, is it not true that Italy has signed a contract with Westinghouse for the construction of a 160,000 kilowatt atomic powerplant in that country?

Mr. McCone. Yes, sir; that is correct.

Mr. Fenton. Is this not an indication then, that United States is successfully competing with Great Britain and other foreign countries?

Mr. McCone. That is right. The success of the Westinghouse Co. and the General Electric Co. in those negotiations with Italy have been indications of success. There have been others, too. The Westinghouse Co. has a contract to build a reactor in Belgium and there are any number of smaller reactors, test reactors, experimental reactors, contracted for research projects throughout the world.

Mr. Fenton. Despite the fact that they have cheaper labor in those countries?

Mr. McCone. We have a certain know-how that gives us an advantage. I have no doubt that as this business evolves that recognizing the fact that reactors are very largely a fabricated product, we will face the prospect of cheaper price from foreign manufacturers who are either developing their own process or are licensed by American manufacturers.

Mr. Fenton. Then the price of labor does not enter into this? I must assume that the United States is pretty far ahead of most of the countries in atomic energy, is that right?

Mr. McCone. I feel that the United States in the development of its technology is as advanced, if not more advanced, than any other country. As I have said, it is not supporting as large a program on a straight kilowatt basis for the reason that our economics in the power business differ from other countries.

However, we are developing several different types of reactors and you are familiar with them. I think this has been a good approach to this problem.

Mr. Fenton. There is no doubt in my mind that the United States could compete with any of them.

Mr. McCone. I have no doubt about that. What I was saying was because our conventional power is cheaper in this country than in any other major country in the world there is not the urgency to develop nuclear power as additional sources of energy.

Mr. Fenton. I understand that. You're absolutely right.

BARTER AGREEMENT WITH GREAT BRITAIN

Now, Mr. Chairman, it has been reported that the Atomic Energy Commission recently signed a barter agreement with Britain which provides for an exchange ratio of 1.76 grams of U^{235} from the United States for 1 gram of British plutonium.

Mr. McCone. Yes, that is correct. That is a treaty that is now before the Joint Committee for its consideration. It involves exchanges of several materials and also the sale to Britain of certain materials.

Mr. Fenton. How does the barter ratio compare with the relative cost of producing the specified grade of each of these materials at U.S. plants and the relative value of each material as atomic power fuel?

Mr. McCone. The ratio of 1.76 to 1 is attractive from our standpoint.

Mr. Fenton. Was this barter necessary?

Mr. McCone. Yes, I think it was necessary in our mutual defense.

Mr. Fenton. Thank you.

That is all.

The CHAIRMAN. Mr. Pillion?

Mr. PILLION. Mr. Chairman, I think each member of the committee appreciates as much as I do your very fine and clear and consistent statement of this afternoon.

EXTENT OF RUSSIAN EFFORT

Mr. Chairman, do we have any figures as to how much Russia spends on the various activities that we have in this $3 billion budget?

Mr. MCCONE. No, we have no figure.

Mr. PILLION. You have no idea whether they spend $6 billion for the same activities or $1 billion?

Mr. MCCONE. No, we have no figures on that at all. Their expenditures are not identified in their total budget in a way that we could identify them.

Mr. PILLION. I am sure you have no figures on Red China.

Mr. MCCONE. That's right.

Mr. PILLION. Do they have an atomic program at this time?

Mr. MCCONE. We must assume that they do have some effort in that area.

Mr. PILLION. They have about as much as the Russians want to give them, I suppose.

Mr. MCCONE. The only means of comparison that we might have is by visits to their laboratories which our people make from time to time. That evidence is that Russia has a very substantial effort. I do not want to minimize it. What it is in dollars, I can't tell you.

TESTING BAN

Mr. PILLION. Has there been any indication from any of our studies whether any bombs have been exploded over Red China or Siberia or Russia?

Mr. MCCONE. The test program that the Russians carried out last October was up in the extreme north of Russia, very well up into the Arctic.

Mr. PILLION. If we were to agree upon a ban of nuclear tests with Russia, and Red China had an atomic program, we would not be very well off would we if Red China were not included in the agreement to limit or to stop all nuclear testing?

Mr. MCCONE. We would be able to detect any tests in the atmosphere in Red China. If tests were conducted under-ground in Red China, I think it would be very questionable whether we could detect them or not.

Mr. PILLION. Mr. Chairman, we have a self-imposed unilateral ban upon our own nuclear testing which we started last October; is that right?

Mr. MCCONE. That is correct.

Mr. PILLION. Would you recommend a continuation of that unilateral ban upon testing after this expires?

Mr. MCCONE. No, I would not continue the present type of ban. I would think that at the end of the year this policy should be very carefully reconsidered. I feel that we have been extremely patient in those negotiations and I do not think that we should find ourselves in a

position of stopping testing just for the purpose of sitting in a conference table.

Mr. PILLION. I read in a sheet that came to my office a few days ago that the Russians are now publicizing instructions for their military as to the use for tactical purposes of nuclear weapons which, of course, indicates that they must have these tactical weapons on hand ready for their military.

Is the ban on our nuclear testing hindering or delaying the development of our atomic tactical weapons any?

Mr. MCCONE. Yes, to an extent. I think that with further testing we could develop improved weapons and we could develop, very possibly develop clean weapons. All of this would depend on further testing.

SALE OF REACTOR FUEL

Mr. PILLION. Do you sell reactor fuel to foreign countries, also? For instance, Italy, where will they buy their fuel?

Mr. MCCONE. Their fuel will be purchased from us under the terms of bilateral agreements which are in existence with a number of countries. This provides for the sale to the countries specified maximum amounts of fuel of relatively low enrichment.

Mr. PILLION. Are we competitive with England in the price that we sell this material?

Mr. MCCONE. So far as I know, our production costs will be very much lower than England's. I do not know that they nor Russia have established a price. For that matter, we have not either, except on a spot basis; we have not committed on any long-range basis.

Mr. PILLION. Does Russia offer the sale of fuel?

Mr. MCCONE. It has not.

Mr. PILLION. Has any country that you know of?

Mr. MCCONE. Not to my knowledge. Undoubtedly, it has supplied fuel to the reactors in satellite countries, but I do not think it has offered any fuel outside. I have heard of none.

COST OF NUCLEAR POWERPLANTS

Mr. PILLION. How does the cost of a nuclear plant compare with the cost of a hydro powerplant in this country? In other words, what was the cost of the 160,000-kilowatt nuclear plant in Italy? Do you have any idea of that, how many hundred dollars per kilowatt capacity?

Mr. MCCONE. We have those figures. The cost of these plants now is running in the order indicated, in the order of $250 to $300 a kilowatt. Now, I have no figures on hydroelectric plants because that ties into the whole development of the dam and the project but steam plants, modern steam plants of comparable size, would run into the order of $150 per kilowatt, more or less, depending on the particular location.

Mr. PILLION. I assume that hydro costs will run somewhere between $250 and $300. Now, how does the cost of fuel compare with the cost of, say, coal?

Mr. MCCONE. At the present time the cost of fuel is relatively high, not because the uranium 235 is so high, but the cost of fabricating and

processing and handling the fuel element and particularly reprocessing of it after it has been partially burned, is expensive.

All of these costs will come down very substantially as we get more production and, thereafter, have the opportunity of continuous operation. Just looking at some figures here, in this particular plant of General Electric's in Italy, the fuel costs just about 4 mills. The cost of the plant will be just about $250, maybe a little less, per kilowatt. Now, 4-mill fuel is about $6 coal, just picking it out of the air, will be the equivalent of coal at $6 a ton.

Mr. PILLION. Are your costs accurate? Do you take into consideration all the elements when you are talking about your costs or do you just take a special small part of your cost? Are you fairly accurate and take into consideration everything in talking about 4-mill cost for your fuel?

Mr. MCCONE. On these studies from which we develop the costs that I reported to you, we were quite careful to see that all costs were included, the amortization and the interest, the interest during construction, the estimated operating cost, the escallation in construction over the 3 of 4-year building period was included. The only place where you might consider that we did not have a true cost is that we figured the fuel on a lease basis as provided in the law because it cannot now be sold, and that being on a 4 percent basis, throws an advantage to the nuclear plant as contrasted with the conventional plant where you have to buy and pay for your oil or your coal.

URANIUM SUPPLY AND COSTS

Mr. PILLION. Is it true that your average cost for uranium at the present time is about $16,000 a ton.

Mr. MCCONE. Our market price—yes, that is correct, for uranium oxide. Our price averages a little more than $8 a pound.

Mr. JOHNSON. That is correct. The average for all material, foreign and domestic, is above $9 but our average domestic price is now in the $8 range and we will soon be approaching an $8 price.

Mr. PILLION. With 33,000 tons a year you are spending around $500 million for material, is that right?

Mr. MCCONE. More than that. This year's estimate is $738.6 million. There are probably some charges in there quite aside from the actual bill for the oxide.

Mr. PILLION. Suppose you had 10 times as much call for reactor fuels as you have today, you would probably have a saving of 25 to 50 percent on the atomic fuel. Is that a reasonable prospect?

Mr. MCCONE. It will come down; the total fuel cost will come down on several fronts. In the first place, with our gaseous diffusion plants operating as they are now, we can reduce our base price somewhat. Then with additional quantity production the cost of fabricating will come down and also the cost of chemical reprocessing and refabrication, all of which go into this 4-cent figure, it will all come down.

Mr. PILLION. Let me ask you this: If you had no contracts outstanding and you just let the market, competitive market, act on a supply and demand basis, how low would the cost of uranium ore get? Where would it drop?

Mr. MCCONE. That is hard to venture a guess on.

Mr. PILLION. I want to get the economics of this peaceful use of energy. Suppose the Commission said instead of paying $16,000 for ore of a certain content we will take bids, take the lowest, the most efficient operation is where we will buy it; we will buy it at the cheapest price.

What is the cost in the most efficient mines or operation that will take care of your needs whether it is 20,000 or 30,000 tons per year? Where would the price go?

Mr. JOHNSON. I would doubt that the lowest cost would support a continuing industry.

Mr. PILLION. I am not talking about supporting an industry. I am talking about the supply and demand in the regular market like we buy and sell coal.

Mr. JOHNSON. With the demand such as we have now I would doubt if the price could hold for any length of time below an $8 figure and over a period of time it might go up. The costs of metal production are greatly dependent on what nature did. Some mines have very low costs and there always are some marginal mines in operation.

The lowest cost production available today would be from amortized plants that were living off of ore reserves developed in the past. I would think that around $6 would be the cost for some of the very low cost producers and in a few cases of byproduct mines it might be possible for costs to be even lower, but this would not be for a large quantity of uranium in relation to the present supply.

Mr. JENSEN. Will the gentleman yield?

Mr. PILLION. Surely.

Mr. JENSEN. If the owners of the uranium mines were to depend on the open market price, would it not bring about a condition where there would be no uranium mined and hence, there would be no uranium supplied for the Armed Forces or for civilian use and we would wind up——

Mr. JOHNSON. If I understand your question, if it were not for the atomic weapons program, there would be no uranium supplies available today to support a major power program. It would be necessary to develop sources of production. If the Commission had not undertaken an aggressive program to develop uranium production we would have exhausted the few sources that had developed ore reserves at the time the program began in, say, 1948.

The two mines that supported 95 percent of the Commission requirements in 1948 today are approaching exhaustion. About 70 percent of present uranium production in the United States, for example, is coming from deposits that have been found within the last 5 years.

Mr. JENSEN. I think Mr. Pillion wants to carry on. Off the record.

(Discussion off the record.)

Mr. PILLION. What are the reserves of Canada? Do they have a reserve of more than 8 or 10 years?

Mr. JOHNSON. The Canadian reserves in terms of uranium oxide are approximately 400,000 tons of U_3O_8. Our ore reserves are about 80 million tons, but our ore is about 2½ times richer than Canada's, so our 80 million tons contain about 200,000 tons of U_3O_8.

Mr. PILLION. Thank you. That is all.
Mr. CANNON. Thank you, Mr. Chairman.
Mr. MCCONE. Thank you very much, Mr. Chairman.
Mr. CANNON. The committee will resume at 10 o'clock in the morning.

OPERATING EXPENSES

BUDGET SUBMISSION, JANUARY 1959

Program and financing

	Actual, 1958	Estimate, 1959	Estimate, 1960
Program by activities:			
1. Raw materials	$598,552,988	$696,947,000	$739,600,000
2. Special nuclear materials	567,686,083	561,000,000	581,000,000
3. Weapons	433,279,206	541,770,000	517,000,000
4. Reactor development	308,961,635	372,570,000	393,215,000
5. Physical research	90,585,536	128,870,000	151,480,000
6. Biology and medicine	35,338,070	43,242,000	49,000,000
7. Training, education, and information	15,453,864	15,548,000	14,800,000
8. Isotopes development	44,104	3,000,000	6,100,000
9. Community	17,675,265	16,792,000	15,666,000
10. Program direction and administration	45,945,700	49,803,000	52,000,000
11. Security investigations	7,595,731	7,506,000	7,390,000
12. Other costs	6,470,007	5,585,000	5,673,000
Adjustment to prior year costs	2,030,985		
Total program costs [1]	2,129,619,174	2,442,633,000	2,532,924,000
13. Revenues applied (−)	32,729,044	27,720,000	31,415,000
Net program costs	2,096,890,130	2,414,913,000	2,501,509,000
14. Relation of costs to obligations:			
Obligations incurred for costs of other years, net	77,284,228	[2] 39,303,950	18,491,000
Total program (obligations)	2,174,174,358	2,454,216,950	2,520,000,000
Financing:			
Comparative transfer to other accounts	2,764,843		
1959 appropriation available in 1958	−1,129,167	1,129,167	
Unobligated balance no longer available	77,940,117	18,000,000	
New obligational authority	2,253,750,151	2,473,346,117	2,520,000,000
New obligational authority:			
Appropriation	2,215,470,000	2,397,406,000	2,502,000,000
Transfer to "Salaries and expenses, National Science Foundation" (72 Stat. 880)		−2,000,000	
Appropriation (adjusted)	2,215,470,000	2,395,406,000	2,502,000,000
Reappropriation	38,280,151	77,940,117	18,000,000

[1] Includes capital outlay for equipment: 1958, $79,391,473; 1959, $91,834,000; 1960, $94,586,000.
[2] Includes $4,000,000 for Euratom which must be authorized.

Proposed for later transmission—Under proposed legislation

	Actual, 1958	Estimate, 1959	Estimate, 1960
Program by activities:			
1. Reactor development			$8,000,000
Net program costs			8,000,000
2. Relation of costs to obligations:			
Obligations incurred for costs of other years, net			15,500,000
Total program (obligations)			23,500,000
Financing:			
Proposed supplemental appropriation (new obligational authority)			23,500,000

Object classification

	Actual, 1958	Estimate, 1959	Estimate, 1960
ATOMIC ENERGY COMMISSION			
Total number permanent positions	7,480	7,360	7,360
Full-time equivalent of all other positions	80	82	71
Average number of all employees	6,865	6,932	6,968
Number of employees at end of year	7,107	6,956	7,077
Average grade and salary, grades established by the Atomic Energy Commission	8.6 $6,350	8.8 $7,231	8.8 $7,316
01 Personal services:			
Permanent positions	$44,373,713	$48,636,000	$49,831,000
Positions other than permanent	452,200	499,000	471,000
Other personal services	1,974,169	2,119,000	2,448,000
Total personal services	46,800,082	51,254,000	52,750,000
02 Travel	2,992,777	3,280,000	3,550,000
03 Transportation of things	6,092,532	7,986,000	7,911,000
04 Communication services	3,817,407	4,135,000	4,721,000
05 Rents and utility services	213,181,121	213,953,000	219,822,000
06 Printing and reproduction	514,533	528,000	576,000
07 Other contractual services	1,160,390,603	1,308,533,219	1,290,404,500
Services performed by other agencies	27,648,830	28,586,000	28,520,000
08 Supplies and materials	612,200,991	709,723,000	769,265,000
09 Equipment	74,251,006	92,213,000	104,999,000
11 Grants, subsidies, and contributions	3,972,652	4,267,000	3,954,000
13 Refunds, awards, and indemnities	94,093	73,000	100,000
15 Taxes and assessments	5,586	7,500	7,500
Unvouchered	18	100,000	100,000
Total obligations, Atomic Energy Commission	2,151,962,231	2,424,638,719	2,486,680,000
Allocations from "Operating expenses, Atomic Energy Commission":			
Total number of permanent positions	40	42	42
Full-time equivalent of all other positions	1	1	1
Average number of all employees	38	41	41
Number of employees at end of year	36	43	43
Average GS grade and salary	6.3 $4,968	6.5 $5,565	6.5 $5,582
01 Personal services:			
Permanent positions	198,117	242,235	244,460
Positions other than permanent	4,845	4,000	4,000
Other personal services	22,402	21,300	21,460
Total personal services	225,364	267,535	269,920
02 Travel	2,253	1,600	1,600
03 Transportation of things	−3,270	3,500	3,500
04 Communication services	312	475	400
05 Rents and utility services	24,624	6,947	1,100
06 Newspapers and periodicals	−28		
07 Other contractual services	21,411,148	29,161,764	32,995,730
Services performed by other agencies	−4,698		
08 Supplies and materials	46,157	35,162	31,500
09 Equipment	330,674	85,153	
11 Grants, subsidies, and contributions	179,610	16,095	16,250
15 Taxes and assessments	−19		
Total obligations, allocations from the Atomic Energy Commission	22,212,127	29,578,231	33,320,000
Grand total obligations	2,174,174,358	2,454,216,950	2,520,000,000
Obligations are distributed as follows:			
Atomic Energy Commission	2,151,962,231	2,424,638,719	2,486,680,000
Department of State	166,415		
Department of Agriculture: Agricultural Research Service	−4,698		
Department of the Interior:			
U.S. Geological Survey	−9,448	337,348	340,000
Bureau of Mines	132,080	153,662	150,000
Department of the Navy	−175,073		
Department of the Air Force	500,000		
Department of Health, Education, and Welfare: Public Health Service	−599		
Department of the Army	21,603,450	29,087,221	32,830,000

REVISED BUDGET (H. DOC. NO. 179), JUNE 18, 1959

Program and financing

	Original estimate	Revised estimate	Increase or decrease (−)
Program by activities:			
1. Raw materials	$739,600,000	$738,600,000	−$1,000,000
2. Special nuclear materials	581,000,000	568,000,000	−13,000,000
3. Weapons	509,000,000	495,000,000	−14,000,000
4. Reactor development	393,215,000	407,400,000	14,185,000
5. Physical research	151,480,000	153,280,000	1,800,000
6. Biology and medicine	49,000,000	49,000,000	
7. Training, education, and information	14,800,000	14,800,000	
8. Civilian application of isotopes and nuclear explosives	14,100,000	14,100,000	
9. Community	15,666,000	15,666,000	
10. Program direction and administration	52,000,000	52,000,000	
11. Security investigations	7,390,000	7,390,000	
12. Other costs	5,673,000	5,673,000	
Total program costs	2,532,924,000	2,520,909,000	−12,015,000
13. Revenues applied (−)	−31,415,000	−31,415,000	
Total program costs, funded	2,501,509,000	2,489,494,000	−12,015,000
14. Relation of costs to obligations:			
Obligations incurred for costs of other years, net	18,491,000	60,906,000	42,415,000
Total program (obligations)	2,520,000,000	2,550,400,000	30,400,000
Appropriation	2,502,000,000	2,417,300,000	−84,700,000
Reappropriation	18,000,000	133,100,000	115,100,000

Object classification

		Original estimate	Revised estimate	Increase (+) or decrease (−)
	ATOMIC ENERGY COMMISSION			
	Total number of permanent positions	7,360	7,360	
	Full-time equivalent of all other positions	71	71	
	Average number of all employees	6,968	6,968	
	Number of employees at end of year	7,077	7,077	
01	Personal services	$52,750,000	$52,750,000	
02	Travel	3,550,000	3,550,000	
03	Transportation of things	7,911,000	7,911,000	
04	Communication services	4,721,000	4,721,000	
05	Rents and utility services	219,822,000	219,822,000	
06	Printing and reproduction	576,000	576,000	
07	Other contractual services	1,290,414,500	1,329,356,500	$38,942,000
	Services performed by other agencies	28,510,000	28,510,000	
08	Supplies and materials	769,265,000	768,265,000	−1,000,000
09	Equipment	104,999,000	97,457,000	−7,542,000
11	Grants, subsidies, and contributions	3,954,000	3,954,000	
13	Refunds, awards, and indemnities	100,000	100,000	
15	Taxes and assessments	7,500	7,500	
	Unvouchered	100,000	100,000	
	Total, Atomic Energy Commission	2,486,680,000	2,517,080,000	30,400,000
	Transfer appropriations with other agencies	33,320,000	33,320,000	
	Grand total	2,520,000,000	2,550,400,000	30,400,000

Mr. CANNON. We shall now take up the appropriation item "Operating expenses."

Please place in the record at this point House Document No. 179 which contains amendments to proposed appropriations for fiscal year 1960.

[86th Cong., 1st sess., H. Doc. 179]

COMMUNICATION FROM THE PRESIDENT OF THE UNITED STATES TRANSMITTING AMENDMENTS TO THE PROPOSED APPROPRIATIONS PREVIOUSLY TRANSMITTED FOR THE FISCAL YEAR 1960 FOR THE ATOMIC ENERGY COMMISSION, INVOLVING A NET INCREASE OF $83,300,000 IN THE AMOUNTS NOW BEFORE THE CONGRESS IN ITS CONSIDERATION

THE WHITE HOUSE,
Washington, June 18, 1959.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

SIR: I have the honor to transmit herewith amendments to the proposed appropriations previously transmitted for the fiscal year 1960 for the Atomic Energy Commission, involving a net increase of $83,300,000 in the amounts now before the Congress for its consideration.

The details of these proposed amendments, the necessity therefor, and the reasons for their submission at this time are set forth in the attached letter from the Director of the Bureau of the Budget, with whose comments and observations thereon I concur.

Respectfully yours,

DWIGHT D. EISENHOWER.

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington, D.C., June 15, 1959.

THE PRESIDENT,
The White House.

SIR: I have the honor to submit herewith amendments to the proposed appropriations previously transmitted for the fiscal year 1960 for the Atomic Energy Commission, involving a net increase of $83,300,000 in the amounts now before the Congress for its consideration, as follows:

INDEPENDENT OFFICES

ATOMIC ENERGY COMMISSION

Budget page	Heading	Original estimate	Change to—	Decrease
128–129	Operating expenses (Add the following proviso at the end of the paragraph under this head:) *: Provided further, That in the event the Commission deems it desirable to design and construct at a Commission installation any power reactor prototype for which cooperative arrangements are authorized under the Commission's authorization act for the fiscal year 1960, as part of the cooperative power reactor demonstration program, and for which direct construction by the Commission is authorized as an alternative to a cooperative arrangement, not to exceed $16,000,000 of the amount appropriated herein may be transferred to the appropriation for "Plant acquisition and construction".*	$2,502,000,000	$2,417,300,000	$84,700,000

This recommended decrease in the appropriation for "Operating expenses" will be accompanied by an increase in the reappropriation of unobligated balances, which are now expected to be larger than estimated in the January budget, partially because certain work financed in 1959 will not be undertaken until 1960. Except for the carryover of funds to provide for this deferred work, total authorizations for "Operating expenses" would be slightly less than estimated in January, although providing for expansion in certain development programs.

The expansions referred to are for research and development on civilian atomic power reactors; for development work at Stanford University on a high energy linear electron accelerator; and for development of civilian power reactors in cooperation with the European Atomic Energy Community, known as EURATOM, to carry out authorizations set forth in H.R. 7537 and S. 2094.

The proposed provision would permit transfer of $16 million to the appropriation for "Plant acquisition and construction" as would be authorized by section 110(e) of H.R. 7537 and S. 2094.

Budget page	Heading	Original estimate	Change to—	Increase
132	Plant acquisition and construction	$102,000,000	$270,000,000	$168,000,000

This amendment provides necessary funding to carry out the new construction projects for which appropriations would be authorized by H.R. 7537 and S. 2094. Of the $168 million additional now requested, $126 million was proposed for later transmission in the January budget. The increase over the $126 million anticipated in January is primarily for facilities to support the civilian atomic power program and the physical research program.

The net effect of these two amendments is to place before the Congress total appropriation requests for the Atomic Energy Commission which are $66,200,000 less than the total estimated for such appropriations in the 1960 budget. Total new obligational authority is estimated to be somewhat greater due to the larger carryover and reappropriation of unobligated balances from the fiscal year 1959. Total estimated expenditures remain essentially the same as anticipated in the January budget.

I recommend that the foregoing amendments for the fiscal year 1960 be transmitted to the Congress.

Respectfully yours,

MAURICE H. STANS,
Director of the Bureau of the Budget.

GENERAL STATEMENT

Mr. CANNON. We shall insert the general statement appearing on pages 1 through 116 of the justifications into the record at this point.

(The matter referred to follows:)

GENERAL STATEMENT

Estimate of appropriation

This book contains the budget estimates for the appropriation "Operating expenses" for fiscal year 1960. The estimates provide for total obligations of $2,550,400,000 to be funded (1) by a new appropriation of $2,417,300,000, and (2) by the reappropriation of $133,100,000 in unobligated balances anticipated at the end of the fiscal year 1959.

Estimates of costs and obligations

The budget estimates for this appropriation are stated in terms of accrued costs for each of the AEC's 12 operating programs. "Accrued costs" denotes the actual application of labor, materials, equipment, and services to the program during the year, but excludes depreciation of facilities used in the operation. The AEC does, however, maintain accounts for depreciation for the purpose of determining total costs of production and for use in establishing prices for services rendered or products sold to others.

Revenues are obtained from the operations of AEC-owned communities and housing, from the sale of products and services performed for others, and from other miscellaneous sources. These revenues are identified and summarized under the section titled, "Revenues Applied." Revenues are deducted from the total of the accrued costs for the operating programs in determining the amount of the net costs to be financed by congressional appropriations.

The net costs of operation are reconciled to the total obligations to be incurred during the year by estimating the buildup or decrease during the year of the resources that are to be applied to future years' operations. These estimates are included in the section titled, "Increase (+) or Decrease (−) in Selected Resources" and include inventories and undelivered orders.

The following table summarizes the accrued costs for each program and the total obligations for the fiscal years 1958, 1959, and 1960. The detailed justifications beginning on page 12 present the programs in the same order as they appear on this summary table.

Summary of accrued operating costs by program reconciled to obligations

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Accrued costs by program:			
Raw materials	$598,552,988	$702,100,000	$738,600,000
Special nuclear materials	567,686,083	545,000,000	568,000,000
Weapons	432,953,001	480,000,000	495,000,000
Reactor development	308,961,635	342,000,000	407,400,000
Physical research	90,585,536	119,000,000	153,280,000
Biology and medicine	35,338,070	43,242,000	49,000,000
Training, education, and information	15,453,864	13,700,000	14,800,000
Civilian application of isotopes and nuclear explosives	370,309	5,700,000	14,100,000
Community	17,675,265	16,792,000	15,666,000
Program direction and administration	45,945,700	49,803,000	52,000,000
Security investigations	7,595,731	7,506,000	7,390,000
Other costs	6,470,007	6,585,000	5,673,000
Adjustment to prior year costs	2,030,985	0	0
Total accrued costs	2,129,619,174	2,331,428,000	2,520,909,000
Less: Revenues applied	32,729,044	28,720,000	31,415,000
Net accrued costs	2,096,890,130	2,302,708,000	2,489,494,000
Increase or decrease (−) in selected resources	77,284,228	36,408,950	60,906,000
Total obligations for operating expenses	2,174,174,358	2,339,116,950	2,550,400,000

Financing of obligations

The estimated obligations of $2,550,400,000 proposed in the budget estimates for fiscal year 1960 would be financed (1) by a new appropriation of $2,417,300,000 and (2) by the reappropriation of $133,100,000 of unobligated balances estimated to be available at the end of the fiscal year 1959. This financing is summarized in the following table:

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Funds available:			
Unobligated balance, beginning of year (reappropriation)	$38,280,151	$77,940,117	$133,100,000
Appropriation	2,215,470,000	2,397,406,000	2,417,300,000
Transfer to "Salaries and expenses" National Science Foundation (72 Stat. 880)	0	−2,000,000	0
Comparative transfers to other accounts	−2,764,843	0	0
1959 appropriation available in 1958, advance procurement (72 Stat. 98)	1,129,167	−1,129,167	0
Adjusted amount available for obligation	2,252,114,475	2,472,216,950	2,550,400,000
Less: Unobligated balance, end of year	77,940,117	133,100,000	0
Obligations incurred	2,174,174,358	2,339,116,950	2,550,400,000

Included in the $133,100,000 of unobligated balances estimated to be available at the end of fiscal year 1959 and proposed for reappropriation in 1960 is the amount of $27.5 million for the procurement of irradiation space in test and power reactors which was appropriated in 1959 but on which contracts will not be made as of June 30, 1959, and $2.5 million for research and development participation in the Euratom program which was originally for obligation in 1959 but for which contracts will not be made until fiscal year 1960.

Expenditures for operating expenses

Expenditures for operating expenses for fiscal year 1960 are estimated at $2,445 million, an increase of $105 million over the estimate of $2,340 million in fiscal year 1959. Actual expenditures for operating expenses in fiscal year 1958 totaled $2,055,439,896. Unexpended balances are expected to increase from

$700,097,338 at the beginning of fiscal year 1958 to an estimated $926,113,593 at the end of fiscal year 1960 as shown in the following table which depicts the amounts available for expenditure, the expenditures for each year, and the unexpended balances at the end of each year.

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Funds available for expenditure:			
Unexpended balance, beginning of year:			
Obligated	$700,097,338	$821,596,643	$820,713,593
Unobligated balance	38,280,151	77,940,117	133,100,000
New appropriation	2,215,470,000	2,397,406,000	2,417,300,000
Transfer to "Salaries and expenses," National Science Foundation (72 Stat. 880)	0	−2,000,000	
1959 appropriation available in 1958, advance procurement (72 Stat. 98)	1,129,167	−1,129,167	0
Total funds available for expenditure	2,954,976,656	3,293,813,593	3,371,113,593
Less: Expenditures	2,055,439,896	2,340,000,000	2,445,000,000
Unexpended balance, end of year:			
Obligated	821,596,643	820,713,593	926,113,593
Unobligated balance	77,940,117	133,100,000	0
Total unexpended balance	899,536,760	953,813,593	926,113,593

Highlights of operating programs

As shown in the table on page 2, estimates are prepared and presented for (1) each of the Commission's major operating programs, (2) revenues, and (3) changes in selected resources. The highlights of each of these estimates are:

Operating costs

1. *Raw materials program.*—Operating costs for the raw materials program are estimated at $738.6 million in fiscal year 1960, compared with the estimated fiscal year 1959 costs of $702.1 million and actual fiscal year 1958 costs of $598.6 million. The raw materials program includes the procurement of uranium concentrates and ores from foreign and domestic sources and related costs for resource evaluation. The increased quantities of uranium concentrates to be procured in fiscal year 1960 will come principally from the United States.

2. *Special nuclear materials program.*—Operating costs for the special nuclear materials program are estimated at $568 million in fiscal year 1960, compared with the estimated fiscal year 1959 costs of $545 million and actual fiscal year 1958 costs of $567.7 million. The production of special nuclear materials begins with the refinement of uranium concentrates for diffusion plants or reactors. The isotope uranium 235 is extracted in gaseous diffusion plants at Oak Ridge, Tenn., Paducah, Ky., and Portsmouth, Ohio. Plutonium is synthesized in the reactors at Hanford, Wash. and Savannah River, S. C. Improvements in processes for each manufacturing step are aimed at decreases in unit costs, increases in yield and improvements in the quality of products.

3. *Weapons program.*—Operating costs for the weapons program are estimated at $495 million in fiscal year 1960 compared with estimated fiscal year 1959 costs of $480 million and actual fiscal year 1958 costs of $433 million. The weapons program includes the production of atomic weapons, the maintenance of stockpiled weapons in a state of constant readiness, the development and design of new weapon types, and the maintenance of test areas in standby status. Civilian application of nuclear explosives (plowshare) is now included under a separate program; i.e., civilian application of isotopes and nuclear explosives.

4. *Reactor development program.*—Operating costs for the reactor development program are estimated at $407.4 million in fiscal year 1960 compared to estimated fiscal year 1959 costs of $342 million and actual fiscal year 1958 costs of $309 million. Emphasis will continue to be placed on advancing power reactor technology in order to achieve large scale generation of economic electrical energy from atomic reactors. Cooperative endeavors between the Commission and industrial groups will be stressed. Costs for the Euratom program will begin in fiscal year 1960.

The estimates provide for general reactor systems research and development applicable to many reactor designs, fuel cycle development, a program of reactor safety, a program for development of separations systems for processing

irradiated fuel elements, and development of systems for disposal of radioactive wastes.

Work will also be continued on reactors to propel merchant vessels, on reactors to meet military needs for power in remote areas, on reactors to propel naval vessels, military aircraft, and missiles, and on reactors to provide electric power and heat for satellites. This research also provides information useful in the development of civilian power reactors.

Operation of test facilities and experimental reactors will be continued at the National Reactor Testing Station, Idaho.

5. *Physical research program.*—Operating costs for physical research are estimated at $153.3 million in fiscal year 1960 compared with estimated fiscal year 1959 costs of $119 million and actual fiscal year 1958 costs of $90.6 million. The physical research program consists of theoretical and experimental investigations required to support both the Commission's immediate and long-range objectives for utilizing nuclear energy. Advances achieved in the past can be traced back to similar laboratory investigations. In the atomic energy program, research plays a relatively more important role than in other industrial operations of comparable size. The phenomena dealt with are close to the frontiers of science. Unusual materials are employed, and their nuclear as well as their chemical and physical properties must be determined. The temperatures and radiation densities at which these materials are used are outside the range of previous experience in industrial technology.

Research will be continued on the controlled thermonuclear project to eventually achieve production of power through the fusion process.

Research is carried on both by Commission laboratories and by some 100 universities and other independent institutions.

6. *Biology and medicine program.*—Operating costs for biology and medicine are estimated at $49 million for fiscal year 1960, compared with estimated costs of $43.2 million in fiscal year 1959 and actual costs of $35.3 million in fiscal year 1958. Primary program emphasis will continue to be placed on the protection of the health and safety of atomic energy plant workers and the general populace from the hazards of atomic energy operations. Research on radioactive fallout problems and related research in the biological hazards of radiation will continue to be expanded. While the program has been directed toward the fulfillment of requirements developed under production and weapons testing operations, additional emphasis will be placed on research efforts of pertinence in the rapidly growing field of industrial uses of atomic energy. Close liaison will continue to be maintained with the Office of Civil and Defense Mobilization as well as with other agencies performing functions interrelated with Commission biomedical interests.

7. *Training, education, and information program.*—Operating costs for the training, education, and information program are estimated at $14.8 million in fiscal year 1960 compared to estimated fiscal year 1959 costs of $13.7 million and actual fiscal year 1958 costs of $15.5 million. Primary program emphasis will continue to be placed on broadening the base of nuclear technology at home and abroad. Program efforts are directed toward the provision of assistance to colleges and universities in establishing nuclear curriculums; the operation, through contract, of schools and the conduct of specialized courses; offering of graduate fellowships in the nuclear energy field; presentation of international conferences, studies, and exhibits; and the development and dissemination of technical information.

8. *Civilian applications of isotopes and nuclear explosives.*—Operating costs for this program are estimated at $14.1 million in fiscal year 1960 compared to estimated fiscal year 1959 costs of $5.7 million and actual fiscal year 1958 costs of $0.4 million. The civilian applications of isotopes consist of research and development activities required to accelerate realization of the potentially vast nonpower uses of atomic energy. A balanced program is planned including (1) expansion of the technology and utilization of isotopes with particular attention to industrial and commercial opportunities; (2) laying the foundation for large-scale training of persons who can work safely with radiation; (3) encouraging the private production of isotopes; and (4) developing, through research and development activities, application of high level or massive radiation.

The civilian applications of nuclear explosives (called the Plowshare program) provides for the development of the peaceful uses of nuclear explosives including research, development, and testing of devices for specific applications. The program planned will include (1) expansion of theoretical studies and research effort; (2) continuation of research directed toward the design and develop-

ment of industrial prototype devices; (3) investigation of applications relative to the recovery of oil; and (4) experimental effort directed toward power, isotope production, and excavation purposes.

9. *Community.*—The Commission operates under contract the communities of Los Alamos, N. Mex., Oak Ridge, Tenn., and Richland, Wash., and provides limited housing services at Sandia, N. Mex., and in the uranium mining area. Based on anticipated disposal of practically all AEC-owned real estate at Oak Ridge and Richland and resultant reductions in requirements for property maintenance, the estimates for fiscal year 1960 reflect a reduction in gross operating costs. Estimated costs of $15.7 million will be incurred in fiscal year 1960 for community operations compared with estimated fiscal year 1959 costs of $16.8 million and actual fiscal year 1958 costs of $17.7 million.

10. *Program direction and administration.*—Under the general heading of program direction and administration are grouped together the salary costs and other expenses of Commission personnel engaged in general management, executive direction, and technical supervision of program operations; the negotiation and administration of contracts; and other related administrative activities. The corresponding costs for Commission personnel engaged in nonadministrative activities directly related to a specific program are included in that program, as for example, personnel safeguarding classified shipments or providing fire protection for a community. Expenses of personnel and travel of other Government agencies doing work for the Commission are treated as contractual services, are not included in the AEC detail of personal services and travel, and are not included in limitation amounts.

Estimated costs of $52 million will be incurred in fiscal year 1960 for program direction and administration compared with estimated fiscal year 1959 costs of $49.8 million and actual fiscal year 1958 costs of $45.9 million. An increase of 121 employees is budgeted under this program in fiscal year 1960. The increase of $2.2 million provides for salaries, travel, and other costs associated with the higher average employment, and other special requirements which include for the first time a full year's cost of maintenance and operation of the expanded Germantown headquarters. The costs in fiscal year 1960 represent 2.1 percent of total operating costs, compared with an estimated 2.1 percent in fiscal year 1959 and 2.2 percent in fiscal year 1958.

11. *Security investigations.*—Estimated costs of security investigations in fiscal year 1960 are $7.4 million compared with estimated fiscal year 1959 costs of $7.5 million and actual fiscal year 1958 costs of $7.6 million. Under provisions of the Atomic Energy Act, persons to be employed on work involving access to restricted data are required to be cleared for security purposes based on investigations by the Civil Service Commission or the Federal Bureau of Investigation.

12. *Other costs.*—This program includes costs incurred by the Commission in furnishing materials and services to industrial organizations and other private parties apart from those which it provides normally for its own basic program. These costs are incurred only upon the request of others. Charges are made for these materials and services and the revenues derived are included under "Revenues applied." Other costs are estimated to be $5.7 million in fiscal year 1960, compared with $6.6 million in fiscal year 1959 and $6.5 million in fiscal year 1958. The lower estimate in fiscal year 1960 reflects a decrease in estimated heavy water sales.

13. *Revenues applied.*—This program includes (1) income from sales and lease of products, and services rendered, (2) revenues from communities, and (3) other miscellaneous income items. These revenues are applied against Atomic Energy Commission appropriation requirements. Revenues are estimated at $31.4 million for fiscal year 1960, compared to an estimate of $28.7 million for fiscal year 1959, reflecting principally increase in sales and lease of materials and lower community revenues. Revenues for fiscal year 1958 were $32.7 million.

14. *Selected resources.*—This program includes inventory stock held by the AEC and its contractors, collateral funds, and goods and services on order or under contract. The appropriation requirements for these items are based on the changes in balances from the previous fiscal year. Selected resources at the end of fiscal year 1960 are estimated at $960.9 million as compared with $900 million in fiscal year 1959 and $863.6 million in fiscal year 1958. The increase of $60.9 million in fiscal year 1960 is related principally to expanded research and development effort on the reactor development program, production of weapons to meet military requirements, increases in funding levels for the cooperative arrangements program for civilian power, and increases for space in test and power reactors.

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JUSTIFICATION FOR PROPOSED LANGUAGE CHANGES

Operating expenses

The proposed changes in the appropriation language for operating expenses are described below. Language enclosed in brackets [ ] indicates proposed deletions; language in italic indicates proposed insertions.

1. "not to exceed [$3,850,000] *$3,550,000* for expenses of travel [, including expenses of attendance at meetings of organizations concerned with the function or activity for which this appropriation is made];"

This monetary change is in accordance with the estimated requirements in fiscal year 1960 for expenses of travel as set forth in the detailed estimates.

The language included in prior appropriation acts which permitted the funds made available for travel to be used for expenses of attendance at meetings of organizations concerned with the function or activity for which the appropriation is made is no longer required as such authority has been granted to all agencies by means of Public Law 85-507, Government Employees Training Act, which was approved July 7, 1958. Subsection 19(b) of that law provides as follows:

"Hereafter any appropriation available to any department for expenses of travel shall be available for expenses of attendance at meetings which are concerned with the functions or activities for which the appropriation is made or which will contribute to improved conduct, supervision, or management of those functons or activities."

2. "not to exceed [$46,800,000] *$52,750,000* for personal services;"

This change is in line with the estimated requirements in fiscal year 1960 for personal services as set forth in the detailed estimates.

3. "purchase (not to exceed [four hundred and thirty-five] *three hundred and ninety-six of which three hundred and sixty-six* are for replacement only, including one at not to exceed [$3,500] *$4,000*) and hire of passenger motor vehicles;"

This provides for the fiscal year 1960 requirement for 396 passenger motor vehicles including the replacement of 366 passenger motor vehicles. The vehicles being replaced are eligible for replacement under the replacement standards established by the General Services Administration. Twenty-nine of the thirty additional vehicles are required to support expanding operations at the NRTS, Idaho; the remaining one is required at Schenectady operations office to provide additional access to the West Milton site. The passenger vehicle fleet at the beginning of fiscal year 1960 will consist of 2,114 vehicles. Of this number, 366 will be disposed of and replaced. With the addition of 30 vehicles the passenger motor vehicle fleet at the end of 1960 will consist of 2,144 vehicles.

The General Government Matters Appropriation Act for fiscal year 1958 established a limitation of $1,500 on the purchase of a passenger motor vehicle unless otherwise specifically provided. The proposed language would provide authority for purchasing one passenger motor vehicle at a cost of not to exceed $4,000. This vehicle is required at headquarters to provide transportation for the five AEC Commissioners to and from official meetings in Washington. It will replace a similar vehicle currently eligible for and requiring replacement.

4. "[$2,397,406,000] *$2,417,300,000* together with the unexpended balances, as of June 30, [1958] *1959*, of prior year appropriations made available under this head to the Atomic Energy Commission * * *."

This change provides for the insertion of the amount requested to be appropriated for fiscal year 1960 and continues to provide for the reappropriation of unexpended balances which has been in effect since 1950.

5. "[That of the funds appropriated herein, $2,000,000 shall be transferred to and merged with funds appropriated to the National Science Foundation: Provided further, That $3,000,000 of the funds appropriated in this paragraph shall be available only upon enactment of S. 4273 or H.R. 13749 for research and development costs in connection with agreements for cooperation with the European Atomic Energy Community: Provided further,]"

This change eliminates language for which there is no requirement in fiscal year 1960.

6. "*Provided further, That in the event the Commission deems it desirable to design and construct at a Commission installation any power reactor prototype for which cooperative arrangements are authorized under the Commission's Authorization Act for fiscal year 1960, as part of the Cooperative Power Reactor Demonstration Program, and for which direct construction by the Commission is authorized as an alternative to a cooperative arrangement, not to exceed*

$16,000,000 of the amount appropriated herein may be transferred to the appropriation for plant acquisition and construction."

In the Commission's Authorization Act for 1960 as passed by the Congress, under section 110(e), the Commission has authority to construct at its own installations prototype power reactors, in the event no satisfactory proposals are received from utilities for civilian prototype power reactor construction under a cooperative arrangement program authorized in the amount of $55.5 million in the 1960 act. The Commission's fiscal year 1960 appropriation request for operating expenses include $16 million for research and development assistance either under third round proposals or unsolicited proposals, exclusive of $14.5 million earmarked for the advanced high temperature gas-cooled reactor arrangement already approved by the Joint Committee on Atomic Energy as an acceptable proposal. The foregoing language change would allow the Commission to transfer funds from the operating expenses appropriation to the appropriation for plant acquisition and construction. This transfer authority is necessary if the Commission is to exercise the authority of section 110(e) which provides that in the event the Commission solicits proposals for any prototype power reactors under the second and third rounds of the cooperative power reactor demonstration program, but no satisfactory proposal is received, the Commission may, if the project is still deemed desirable, proceed with design, construction, and operation of such prototype at a Commission installation.

General provisions

The proposed change in the language for the general provisions is described below. Language enclosed in brackets [ ] indicates proposed deletions; language in italic indicates proposed insertions.

1. "Any appropriation available under this or any other Act to the Atomic Energy Commission may initially be used subject to limitations in this Act during the fiscal year [1959] *1960* to finance the procurement of materials, services, or other costs which are a part of work or activities for which funds have been provided in any other appropriation available to the Commission: * * *"

The change continues, in fiscal year 1960, this provision which has been in effect since fiscal year 1953.

2. "* * * *Provided*, That appropriate transfers or adjustments between such appropriations shall subsequently be made for such costs on the basis of actual application determined in accordance with [general] *generally* accepted accounting principles."

The change is to correct what appears to have been an error in printing Public Law 85-766, Supplemental Appropriation Act, 1959. Prior-year appropriation acts and H.R. 13450, which became Public Law 85-766 after passage, contained the word, "generally."

WEDNESDAY JUNE 24, 1959.

UNOBLIGATED BALANCES

Mr. CANNON. Resuming our hearing on the budget estimates for the Atomic Energy Commission, you request nearly $2½ billion, and there is a reappropriation of $133,100,000. The unobligated balance then is to be added.

Now we would like you to give us for the record here, if you will, a tabulation of the slippage items which make up this unobligated balance, and tell us why you have all this money left over for the current year 1959. That is quite a substantial sum to be carried over. Did we give you too much?

General LUEDECKE. I will have the budget officer, Mr. McCarthy, respond to that.

Mr. MCCARTHY. We will insert the tabulation in the record, Mr. Chairman.

(The tabulation referred to follows:)

Analysis of carryover

[Millions]

	Fiscal year 1959 as approved and adjusted by comparabilities	Current estimate	Change
Operating costs:			
Raw materials	$680.2	$702.1	$+21.9
Special nuclear materials	570.2	545.0	−25.2
Weapons (excluding Plowshare)	538.6	480.0	−58.6
Reactor development	376.8	342.0	−34.8
Physical research	128.9	119.0	−9.9
Project Sherwood	(39.9)	(30.0)	(−9.9)
All other	(89.0)	(89.0)	(0)
Biology and medicine	43.2	43.2	0
Training, education, and information	16.0	13.7	−2.3
Civilian application of isotopes and nuclear explosives	7.5	5.7	−1.8
Community	15.1	16.8	+1.7
Program direction and administration	49.8	49.8	0
Security investigations	6.9	7.5	+0.6
Other costs	6.7	6.6	−0.1
Total operating costs	2,439.9	2,331.4	−108.5
Less revenues	−27.7	−28.7	−1.0
Net operating costs	2,412.2	2,302.7	−109.5
Increase or decrease in selected resources	39.0	36.4	−2.6
Total obligations	2,451.2	2,339.1	−112.1
Carryovers:			
Beginning of year	−56.9	−77.9	−21.0
End of year	0	+133.1	+133.1
Net carryover	−56.9	+55.2	+112.1
New funding	[1] 2,394.3	[1] 2,394.3	0

[1] Excludes $2,000,000 transferred to National Science Foundation; and $1,129,167 obligated in 1958 under authority for advance procurement.

Mr. McCarthy. The $133 million, Mr. Chairman, is made up of three parts, if you will. Last year when we came before your committee, we estimated for reappropriation an amount of some $56 million. This turned out to be at the beginning of this current fiscal year $77 million, or $21 million greater than we had anticipated last year when we were before your committee. This, of course, has not been touched. It has been held in reserve for application during the current year with the new appropriation request.

There was also $30 million of items which we had planned in our program of 1959, $27.5 million pertained to the obligation of the test phase in reactors which we did not obligate this year, and $3 million for Euratom, which is not underway.

The balance of the program represents underruns in our costs in our various programs. The largest one, of course, is in our weapons program. We underran moneys there. We underran the reactor development program. We did have an increase in our raw materials which was offset by some of these decreases. The tabulation in the record will show for each program the estimated amount, approved by the Congress, and our estimate for the current year as we now see it and the change. This will show the change in the various programs.

Mr. Cannon. Heretofore, your trend for a number of years has been steadily upward in the cost of material. Now, for the first time, you show a change in the trend, and your reports indicate a drop in the cost of materials. Do you think this is merely temporary, or may we depend on that trend to continue during the coming fiscal year?

Mr. McCarthy. The cost of the raw materials, of course, as you pointed out, will increase during the budget year, that is 1960, over the current year. The cost of the special nuclear materials program did drop last year. There were a number of reasons for that. One of them is probably some more favorable unit prices than we had anticipated.

There was also the fact that one of our contracts was not delivered to us, the plutonium we buy from Canada, because their reactors were not underway. It is anticipated in this current year we will receive that plutonium. We feel that the changes we have made in the 1960 estimates now reflect our current unit costs and we feel that these are probably good estimates.

NEED FOR ADDITIONAL FUNDS

Mr. Cannon. With this carryover you have considerably over $2.5 billion for the coming fiscal year. Are you inclined to believe you positively will need this entire amount?

Mr. McCarthy. Based on our current review, Mr. Chairman, we feel that we do. We have scanned each of these programs. In 1960 we made some reductions from the President's budget in the operating appropriation to reflect our more current costs.

Mr. Cannon. We do not want you to be fighting the possibility of a carryover at the end of the fiscal year 1960. If there is any way of reducing a carryover, we want to avail ourselves of it. But all things taken into consideration at this time, do you really feel that you will require and that you will use this amount in excess of $2.5 billion?

Mr. McCarthy. Yes, sir; based on the present estimate of obligations in 1960.

Mr. Cannon. Are there any questions?

Mr. Kirwan. I have none.

Mr. Pillion. I have just one question.

Mr. Cannon. Mr. Pillion.

EFFECT OF A $100 MILLION REDUCTION IN THE ESTIMATES

Mr. Pillion. Which would be the least valuable portion of your program in the event you had to cut $100 million from your program. Which part of your program would be most susceptible to a cut?

Mr. McCone. I think that would require a careful review. As I said yesterday, about 75 percent of the total amount is in support of the weapons program. I think that a cut of that magnitude would require a very careful review of the level of support of the weapons program.

Mr. Pillion. Assuming that the weapons program was not touched, is there any area in which you think there is a marginal situation with respect to the use of $100 million? In other words, the least useful, where the least harm would be done.

Mr. McCone. You mean the weapons support untouched?

Mr. Pillion. Yes; intact.

Mr. McCone. It would have a very, very serious effect on essential programs, such as the reactor program, the physical research, biology and medicine, the isotopes program.

LOSS OF COMPETENT PERSONNEL

Mr. PILLION. I was very much and agreeably surprised with the statement concerning Admiral Rickover's staff comprising a couple of hundred men who are doing such a tremendous job. Do you have a system for evaluating the work done by all your employees in that area, say, efficiency, accountability, that sort of thing?

Mr. MCCONE. Yes; we have a system for evaluating and appraising.

Mr. PILLION. Also the productivity of the 7,000 employees?

Mr. MCCONE. I will say that we do have a serious problem in the loss of competent personnel, particularly in the reactor development field, because of the fact that as these men become experienced, industry picks them up. When I took over as Chairman of this Commission just a year ago, the General Manager had left to become the president of a corporation, the Deputy General Manager had left, the Director of the Reactor Division had left, the Deputy Director of the Reactor Division had left, two of the Assistant General Managers had left, and I was a little lonesome out at Germantown for a while. But we got that straightened out. This is a problem. In some ways it is a good kind of problem to have, because the fact that these men can come into the Atomic Energy Commission and after a few years be of value to our whole complex of industry and our enterprise system is a good thing.

Mr. PILLION. It indicates you train them very well.

Mr. MCCONE. But it makes it a little difficult.

Mr. PILLION. I understand.

Mr. MCCONE. However, we are overcoming it.

Mr. PILLION. Thank you very much, Mr. Chairman.

UNEXPENDED BALANCES

Mr. MAGNUSON. Mr. Chairman, do I understand from this that you will have an unexpended balance of almost a billion dollars, $926 million, at the end of fiscal 1960?

Mr. MCCARTHY. That is correct, Mr. Magnuson. You see, a large part of this is tied up at the end of the fiscal year, is obligated under our contracts. In other words, we have almost $600 million of that to carry our major contracts over the 3-month period. The contracts run from October 1 to September 30, so that as of the end of the fiscal year each of our major contractors will have 3 months under their contract which will be obligated, but unexpended on our books. A large part of that money is accounted for in those major contracts, General Electric, Du Pont—all of the major operating contractors of the Commission.

Mr. MAGNUSON. This large reserve in the pipeline is necessary, then, you feel?

Mr. MCCARTHY. One of the problems, of course, in the early days with the major operating contractors was to assure them under their requirements, to assure them sufficient funds to assure them continuity of operation. If you will recall we did have at one time 6 months'

carryover under these contracts. I believe it was the year before last that this committee cut it back to a 3 month carryover. We were at that time carrying the laboratories on a 3-month basis, the production contractors on 6 months. We cut the production contractors back to 3 months in line with the labs. So each of them now has under his contract a 3-month coverage on obligations on our books. This looms awfully large, and this is a major portion of it.

Raw Materials

Mr. Cannon. Taking up the cost of raw materials for the fiscal year 1960, I note you are asking $738,600,000 for that purpose. We shall insert here pages 12 through 23, Mr. Clerk.

(The information referred to follows:)

Raw Materials—Operating Costs

Program statement

Estimate fiscal year 1960	$738,600,000
Estimate fiscal year 1959	702,100,000
Increase	36,500,000

Uranium concentrate procurement in fiscal year 1960 is estimated at 35,915 tons as compared with estimated fiscal year 1959 procurement of 33,135 tons. This, together with other raw materials procurement, is budgeted in fiscal year 1960 at $736,127,000, which represents 99.7 percent of the total cost of the raw materials program. Uranium concentrate costs comprise 96.8 percent of total program costs. The average price per pound is estimated to be moderately lower in fiscal year 1960 than in fiscal year 1959.

The largest tonnage increase in concentrate procurement in fiscal year 1960 will result from additional U.S. production, which is expected to increase 2,345 tons, or 15 percent over the domestic fiscal year 1959 procurement of 15,155 tons. Concentrate procurement from Canada is expected to increase approximately 4 percent, from 13,320 tons in fiscal year 1959 to 13,870 tons in fiscal year 1960. Procurement from oversea sources is expected to be 4,545 tons, approximately the same level as in fiscal year 1959.

Although the greater part of the total cost of $738,600,000 budgeted for the raw materials program in fiscal year 1960 will be incurred for uranium concentrate procurement; funds also will be needed for the procurement of uranium ores, vanadium, thorium, and other special materials. The Commission will continue to acquire at published prices limited quantities of domestic uranium ores which meet specifications. The Commission is committed under certain older uranium procurement contracts to purchase vanadium pentoxide and vanadium tailings generated as a byproduct of uranium concentrate production. Thorium is a material with potential uses in the power reactor and weapons field and is being procured under a Commission stockpile goal, with deliveries being completed in fiscal year 1960.

The resource evaluation program supports the uranium procurement program and is budgeted at $2,168,000 in fiscal year 1960, which is slightly lower than in fiscal year 1959. The principal element of the domestic program is the appraisal of private uranium activities in order to develop uranium resources data required in support of the procurement program and for long-range planning. The foreign resource evaluation program provides for technical assistance to foreign countries in uranium exploration techniques and reconnaissance.

A second supporting program, process development, is budgeted at $250,000 in fiscal year 1960, which is one-half the cost level in fiscal year 1959. Costs under this now relatively small program will be incurred primarily for amenability testing of ores and small-scale pilot testing of uranium extraction processes and for investigations of possible radiation and pollution problems.

Summary of estimates by category

Category	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
1. Resource evaluation	$2,192,240	$2,223,000	$2,168,000
2. Procurement of source materials	594,250,107	699,317,000	736,127,000
3. Process development	1,978,491	500,000	250,000
4. Equipment not included in construction projects	132,150	60,000	55,000
Total, raw materials program	598,552,988	702,100,000	738,600,000

1. Resources evaluation, $2,168,000

(*a*) *Domestic, $1,955,000.*—The chief functions of this program are appraisals of private exploration and mining operations, the development of ore reserve estimates and the evaluation of potential resources. This information is essential to the administration of outstanding programs and contracts, to the negotiation of contract amendments and new contracts, and to the planning of current and future production schedules and capabilities. In addition, this program provides an evaluation of developments in uranium geology and exploration techniques and their application to the appraisal of potential uranium resources and production relative to long-term projections of uranium requirements.

Actual costs for fiscal year 1958 and estimates for fiscal years 1959 and 1960 for the domestic resource evaluation program follow:

Fiscal year 1958	$2,048,582
Fiscal year 1959	1,985,000
Fiscal year 1960	1,955,000

Costs of the domestic program will remain approximately the same in fiscal year 1960, as in fiscal year 1959.

(*b*) *Foreign, $213,000.*—Foreign program costs in fiscal years 1958 through 1960 are:

Fiscal year 1958	$143,658
Fiscal year 1959	238,000
Fiscal year 1960	213,000

Fiscal year 1960 costs provide for the salaries, quarters and other allowances, travel and other costs of AEC technical personnel assisting in cooperative uranium evaluation programs in a number of foreign countries. In fiscal year 1960, it is expected that AEC personnel will be stationed in Peru, Chile, and Colombia and will make brief visits to a number of other friendly nations throughout the world.

2. Procurement of source materials, $736,127,000

(*a*) *Uranium concentrates and oxide, $712,754,000.*—Procurement of uranium concentrates is related to the requirements for special nuclear materials for weapons manufacture as determined by programs developed jointly by the Department of Defense and the AEC, and to AEC's requirements for peaceful applications of atomic energy and for research.

The major commitments of the Commission for uranium concentrate procurement are under contracts with: (1) individual private processing mill operators in the United States; (2) the Canadian Government, a separate contract being negotiated for each producing property; and (3) the south African Government (through the Combined Development Agency). The United States and Canadian commitments are under unit price contracts, each of which provides for a specified total maximum tonnage to be delivered during the contract period. Delivery of the total tonnage commitment under each contract is regulated in most U.S. contracts by limiting the quantity of uranium ores that may be fed to process during each 3-month period throughout the period of the contract. Underlying each contract with the Canadian Government for a producing property is, by reference a contract between that Government and the individual producer which specifies approximate monthly rates of delivery. The South African agreement is a cost type, but not a cost-plus agreement in that if production costs are reduced, mine profits increase, and the price paid by the Commission decreases.

By agreement of May 1958, an annual ceiling was placed on South African deliveries effective with fiscal year 1959.

The above-described contractual commitments constitute a firm obligation of the Commission. However, the 1960 budget estimates for uranium procurement assume that negotiations, presently underway, with domestic uranium processing contractors will result in the deferment beyond fiscal year 1960 of the delivery of some 1,100 tons of concentrates which otherwise might be provided in the estimates. The negotiations now being conducted are aimed at a stretchout of concentrate deliveries under existing contracts in order to bring the Commission's annual procurement of uranium concentrates more nearly into balance with annual production requirements.

It is pointed out that no new commitments for South African or other oversea uranium concentrate procurement have been made during the past 3 years. In the case of Canada, contracts have been executed covering firm commitments made to the Canadian Government in prior years.

New milling contracts or amendments to existing contracts are contemplated for production from private mill operators in the United States under the approved overall domestic program announced November 24, 1958. The announcement provided for limited procurement from ore reserves developed prior to that date, but also recognized the need for placing definite restrictions on total annual concentrate deliveries.

The following discussion of U^{308} deliveries by major source is based on estimated total deliveries of 35,915 tons in fiscal year 1960:

United States: The largest production increase is expected to occur in the United States. Six additional processing mills began producing in fiscal year 1959 and 3 more are expected to enter production in fiscal year 1960, bringing the total number of mills throughout the western United States to 27 in fiscal year 1960. These new mills are expected to increase U.S. concentrate production in fiscal year 1959 by 48 percent over fiscal year 1958, and fiscal year 1960 production by 2,345 tons, or 15 percent over fiscal year 1959. A very small production of concentrates from domestic phosphatic sources is included in the U.S. estimates.

One thousand five hundred tons of the current estimated deliveries of concentrates by U.S. producers of 17,500 tons in fiscal year 1960 will be acquired under the limited expansion program announced in April 1958. Authorization of this expansion revised the policy announced in October 1957 of negotiating no new contracts for delivery of concentrates prior to 1962 which involved additional milling capacity, in order to avoid overproduction and excessive procurement by the Commission. A study of the effect on the uranium industry of the October 1957 policy indicated the need for additional ore markets in several producing areas. Procurement under the limited expansion, as announced April 2, 1958, is expected to result ultimately in deliveries of approximately 2,900 tons of U^{308} annually.

Canada: Deliveries in fiscal 1960 from the 16 processing plants in Canada are expected to increase 4 percent as a result of all plants producing at scheduled levels. A substantial part of Canada's production in fiscal year 1960 will be sold directly to the United Kingdom, in accordance with an arrangement negotiated between the United States, Canada, and the United Kingdom.

Overseas: Total U^{308} procurement in fiscal year 1960 from oversea sources through the Combined Development Agency (a joint United States-United Kingdom purchasing agency) is expected to be at approximately the same level as fiscal year 1959. The principal producer of oversea procurement is South Africa. Additionally the Belgian Congo, Portugal, and Australia will continue as producers in fiscal year 1960.

The costs of uranium concentrate procurement from the United States, Canada, and oversea sources for fiscal year 1958, fiscal year 1959, and fiscal year 1960 are set forth in the following table:

	Fiscal year 1958			Fiscal year 1959			Fiscal year 1960		
	Tons U^{308}	Unit price (per pound)	Cost	Tons U^{308}	Unit price (per pound)	Cost	Tons U^{308}	Unit price (per pound)	Cost
			Thousands			*Thousands*			*Thousands*
United States	10,243	$9.57	$196,014	15,155	$9.24	$279,968	17,500	$8.88	$310,765
Canada	9,475	10.77	204,104	13,320	10.83	288,472	13,870	10.57	293,078
Overseas	6,657	11.76	156,520	4,660	11.91	111,013	4,545	11.97	108,805
Total, uranium concentrates	26,375	10.55	556,638	33,135	10.25	679,453	35,915	9.92	712,648
Add: Refining costs: Canada and Belgian Congo in fiscal years 1959 and 1960 (upgrading U^{308} to U^{30})			5,582			6,067			5,963
Deduct:									
Usage of uranium ores			7,157			3,040			1,200
Sale of uranium ores to domestic processing mills			9,919			10,345			4,657
Total, uranium concentrates cost, net			545,144			672,135			712,754

The average price paid for domestic uranium concentrates continues to decline, reflecting the improved metallurgy and larger capacity of the new mills, despite higher labor and material costs.

It will be noted that in all 3 fiscal years the average unit price paid for U.S. uranium concentrates is lower than the average price paid for concentrates from foreign sources. This is due primarily to differences in the grades of ores processed. Dometic ores give an average recovery of about 5 pounds of U^{308} per ton, in Canada the average is about 2 pounds per ton, and in South Africa about one-half pound per ton. In other words, for each ton of domestic ore mined and milled, Canada must mine and mill an average of 2½ tons and South Africa 10 tons to obtain the equivalent uranium production.

Lesser sales of uranium ore to domestic mill processors (a credit to concentrate procurement costs) under commitments contained in uranium milling contracts will increase fiscal year 1960 concentrates costs approximately $5.7 million over fiscal year 1959.

Additional information of a classified nature is presented on page 24.

(*b*) *Uranium ores, $9,034,000.*—The Commission is committed to purchase at published prices limited quantities of domestic uranium ores which meet specifications. Industry is at present buying more than 95 percent of all uranium ore mined. Procurement of uranium ores by the AEC in fiscal year 1960 will increase as the result of purchases at Moab, Utah. These purchases will be necessary to provide a market for ore producers in the Moab, Utah, area, as indicated by the April 2, 1958, limited expansion program, and at the same time, to preclude the addition of new mill facilities or expansion in concentrate production in this area. The ores will be sold to milling companies after 1962 at not less than full inbound costs.

AEC ore procurement in the 3 fiscal years is shown in the following table:

Fiscal year 1958:	
Tons ore	336,505
Price per ton	$35.99
Cost	$12,112,000
Fiscal year 1959:	
Tons ore	53,200
Price per ton	$34.68
Cost	$1,835,000
Fiscal year 1960:	
Tons ore	241,000
Price per ton	$37.49
Cost	$9,034,000

Higher price per ton in fiscal year 1960 is based on purchases of higher grade ore in the Moab area.

(*c*) *Bonus incentive for initial production, $1,647,000.*—Under the terms of AEC's Domestic Uranium Program Circular 6, which expires March 31, 1960, a graduated bonus of up to $35,000, depending upon the quantity and grade of ore, is paid for the initial 10,000 pounds of U^{308} contained in acceptable ores delivered from a new eligible uranium mine to a buying station or processing mill. Bonus payments have been and will continue to be important by giving financial assistance to the prospector and small miner during the early stages of development and mining. In the case of mines in new areas remote from mills or buying stations, the initial bonus frequently is an important factor in enabling the miner to ship his ore during the development period.

To December 31, 1958, a total of 1,077 mines had been certified as eligible and the full benefit payments allowed had been paid to 271 of those mines. It is expected that in fiscal year 1960 fewer properties will be certified and that payments will be made on only 500,000 pounds of U^{308} as compared with 635,000 pounds in fiscal year 1959. Bonus payments amounted to $2,040,118 in fiscal year 1958 and are estimated to be $2,255,000 in fiscal year 1959.

The bonus incentive program terminates on March 31, 1960, and no extension is contemplated.

(*d*) *Vanadium, $2,588,000.*—Certain unit price domestic uranium concentrate contractors have the option of disposing of the byproduct vanadium pentoxide either on the open market or to the Commission at a fixed contractual price per pound. This contingent liability is a contractual commitment on the part of the Commission. Although 2,893 tons of V^{205} were purchased in fiscal year 1958, provision is made for the purchose of only 1,100 tons in fiscal years 1959 and 1960.

This decrease results from negotiating the deletion of the V^{205} option in one contract, effective July 1, 1958, and from assuming, based on prior years experience, that one-half of the V^{205} production of the two other concentrate contractors having this option will be sold on the open market. Should the market fail to absorb this production, it could result in additional AEC costs of up to $2,250,000 in fiscal years 1959 and 1960.

Only one uranium contract remains in fiscal year 1960 in which payment is made for the vanadium contained in mill tailings instead of for fused vanadium oxide which requires a special milling operation. This type of contract results in a lower cost since the vanadium in tailings is paid for at the AEC's ore-buying schedule price of $0.31 per pound as compared with about $1 a pound for commercial grade fused vanadium.

Actual tonnage and costs in fiscal year 1958 and estimates for fiscal years 1959 and 1960, follow:

	Fiscal year 1958			Fiscal year 1959			Fiscal year 1960		
	Tons	Unit price per pound	Cost (000)	Tons	Unit price per pound	Cost (000)	Tons	Unit price per pound	Cost (000)
Vanadium pentoxide	2,893	$0.99	$5,714	1,140	$0.99	$2,270	1,100	$0.99	$2,192
Vanadium tailings	3,093	.31	1,929	2,560	.31	1,600	639	.31	396
Total			7,643			3,870			2,588

(*e*) *Thorium, $504,000.*—Thorium is a source material procured under a Commission stockpile goal with potential use as a material for power reactors and in the production of U^{233} for weapons use.

The Commission is committed under existing unit-price contracts for the acquisition shown hereafter. With the completion of deliveries scheduled in fiscal year 1960 all contracts will have been completed. No further purchases are contemplated at this time.

	Fiscal year 1958			Fiscal year 1959			Fiscal year 1960		
	Metal tons	Unit price (per pound)	Cost (000)	Metal tons	Unit price (per pound)	Cost (000)	Metal tons	Unit price (per pound)	Cost (000)
United States	40	$5.25	$420	52	$4.85	$504	52	$4.85	$504
Foreign	354	5.43	3,846	19	5.42	206	0	0	0
Total acquisitions	394	5.41	4,266	71	5.00	710	52	4.85	504

The AEC-owned thorium metal content inventory position as of June 30, 1960, after taking the above fiscal year acquisitions into account, is expected to be:

	Tons
Inventory as of June 30, 1958	1,840
Acquisition in fiscal year 1959	71
Acquisition in fiscal year 1960	52
Total inventory as of June 30, 1960	1,963

(*f*) *Other special materials, $9,600,000.*—This activity provides for the procurement of other special materials required in the Commission's production program.

3. Process development, $250,000

Costs under this category will be reduced one-half in fiscal year 1960 as only a limited effort is contemplated in such fields as amenability testing of ores and

small scale pilot plant testing in facilities of the U.S. Bureau of Mines at Salt Lake City, Utah. The principal process development activities carried on at the Raw Materials Development Laboratory at Winchester, Mass., were terminated at the end of fiscal year 1958; however, certain chemical studies concerning health hazard problems related to radioactive substances are being continued.

The major segments of process development costs for fiscal years 1958 through 1960 are as follows:

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Raw Materials Process Development Laboratory, National Lead Co. (chemical studies)	$1,520,926	$300,000	$50,000
Other contractors, principally U.S. Bureau of Mines (domestic ores)	177,126	200,000	200,000
Shales, Columbia University	280,439	0	0
Total process development	1,978,491	500,000	250,000

4. Equipment not included in construction projects, $55,000

Equipment for fiscal year 1960 will be required in support of the uranium concentrate purchase, ore-buying and resource evaluation activities of the raw materials programs. Costs are estimated at $55,000 for fiscal year 1960 as compared to the fiscal year 1959 estimate of $60,000. The following table reflects a comparison by installation of equipment costs with related other operating costs in the raw materials program:

Fiscal year 1960

[In thousands]

	Other operating costs	Equipment costs
(1) Sampling and assaying of concentrates and ores for payment purposes, and ore buying at various locations	$5,393	$15
(2) Resource evaluation geological field equipment	2,223	40
Total	7,616	55

Mr. CANNON. Last year a total of $680 million was appropriated for the raw materials program, at an estimated cost of $702,100,000 for 1959. How do you explain that discrepancy?

General LUEDECKE. 92.6 percent of that amount is expended for uranium concentrate, the ore program that we discussed with you yesterday. The primary reason for the increase is the difference between the 33,435 tons of last year and 35,900 tons that we are committed to this year.

Mr. CANNON. Will this $702,100,000 which you propose to spend for raw materials in the coming fiscal year include this plutonium that you had expected to get from Canada but on which delivery was delayed?

Mr. MCCARTHY. No, sir. That is under the next program, Mr. Chairman. That is under the special nuclear materials program that we procured the plutonium from Canada.

I might say that the increase of $21 million from what the committee saw last year in this program is the receipt of additional ore above that which we estimated when we were before the committee. We received more unranium concentrates than we had projected at that time.

BONUS PAYMENTS

Mr. CANNON. Last year when we had this up, there was some discussion as to bonus payments. Will you bring the committee up to date on your policy on bonus payments?

General LUEDECKE. Mr. Johnson will answer that question.

Mr. CANNON. Mr. Johnson.

Mr. JOHNSON. Mr. Chairman, following the committee action there was again a very careful review of the entire bonus program by the Commission. The result was a conclusion that it appeared advisable to continue the bonus program to its expiration on March 31, 1960, for the reason that a cancellation of the bonus program with respect to those not yet certified would not cover all of those who would be in a position to come in with a claim against the Government on possible legal grounds, to say nothing of bad faith. Termination with regard to future certifications would still leave a number who might come in and claim damages against the Government for having made expenditures in good faith under the bonus program.

The acts that are necessary in order to be certified are the discovery of a deposit, the development of a deposit to a point where it can produce, and then an initial delivery to an official buying station. The certification is not made until the first delivery of ore, and before one can deliver ore, one must find a deposit, must develop it to a sufficient extent so that production can start. Consequently, if the termination is made on the basis of no new certifications undoubtedly there would be a number of claimants who would claim that they would be able to deliver ore, but were denied by reason of the termination, and in cases of that kind it would be extremely difficult to determine what might have been delivered, and there is a possibility that claims may be sustained on the basis of greater deliveries than could actually have been made.

We believe that as far as the current fiscal year is concerned, there will be few, if any, certifications that will not be based upon discoveries made prior to the hearings held last year by this committee, because there is a long interval between the finding of the prospect, the development of a prospect, and the movement of ore to a mill.

AVAILABILITY OF URANIUM

Mr. CANNON. There are still undiscovered areas which you expect to bring into production in the future?

Mr. JOHNSON. It is our view on the basis of the experience of the past several years, and the geological information developed, that there are extensive areas in this country that are favorable for prospecting and development, and that additional deposits in this country will be found. In the foreseeable future we are not likely again to be in a position where we will be dependent upon foreign sources for our uranium to the extent that we have in the past.

Mr. CANNON. Off the record.

(Discussion off the record.)

Mr. KIRWAN. Is it not a fact that we have uranium all over the Nation?

Mr. JOHNSON. Our experience to date does not confirm this, if we refer to deposits that are commercial. Now, there are traces of

uranium in most rocks, including granites. There are huge deposits of black shales in the Tennessee-Kentucky area, but it would take from 20,000 to 30,000 tons of such shale, and these are the highest grade we have found in the United States, to produce 1 ton of uranium oxide, whereas with the types of ores that are being mined in the West, 400 to 500 tons produce 1 ton of uranium oxide.

Mr. KIRWAN. I have heard so many stories about it. I went through uranium mines and refineries in Utah. They tell me that there is enough uranium in this country. We took a plane and we spent 12 hours flying as low as we could over Utah, New Mexico, Arizona, and Nevada, and then came down twice to go through different mines and through the refineries. Everyone connected with this industry stated we have adequate supplies in this country. It is just a matter of exploration to locate the reserves.

Mr. JOHNSON. We have large reserves developed. It is also true that in the areas you speak of, in Utah, in Colorado, there has been more prospecting than in most any other area, because these areas had been looked at for uranium for almost 40 years. The deposits that have been found in these areas are limited. Utah is third on the list of States with developed uranium ore reserves. Colorado is fourth.

Mr. KIRWAN. We have all of it that we need now? We know where to lay our hands on it?

Mr. JOHNSON. We have developed ore reserves sufficient to meet the scheduled production for the next 10 years.

Mr. KIRWAN. At the rate we were going, everybody was coming up with stock for investment in uranium mines. Many would have gone broke if there had not been a stop put to it when the Government notified them that limitations were being placed on the quantity that would be purchased.

Mr. JOHNSON. That is correct. We have put the brakes on in order to hold down our production, and on the basis of the geological information we are optimistic over future discoveries. It is still not a certainty, but I think the geological information points to the fact that many important discoveries will be made in the future.

I also want to point out that the major discoveries that have been made in the last few years have been hidden deposits that have not outcropped or have had very inconspicuous outcrops, so that we may have a difficult problem in maintaining our reserves, in finding subsurface deposits which do not outcrop.

Mr. KIRWAN. It is the same story we have experienced with many minerals. Once you go out and start to investigate and explore, you come up with plenty of it; is that correct?

Mr. JOHNSON. The exploration for uranium in this country has been successful in developing very substantial quantities. Exploration elsewhere has not been so successful.

Mr. KIRWAN. That is all, Mr. Chairman.

RETAINING RESERVES IN THE GROUND

Mr. CANNON. In view of what Mr. Kirwan has said, and he speaks from practical experience, and in view of the fact that you have at present time ample concentrates on hand, would it be better for us

to reserve these supplies in the ground where they now are, instead of at this time encouraging their production and processing?

Mr. JOHNSON. We no longer are encouraging production and processing, but are putting limitations on the quantity that will be purchased, and attempting to reduce the quantity that we will buy through stretchout arrangements and other restrictions within the limits of our contracts and our obligations. We expect to be able to substantially reduce our expenditures for fiscal 1960 on the basis of stretchout negotiations with domestic companies. As stated in our budget, we are requesting funds for something like $20 million less than the amount required to meet our present contractual obligations. But we believe on the basis of the negotiations that are now underway and are well along, that we will be able to hold the fiscal 1960 expenditures to the figures in this budget. It will require, though, approximately a $20 million cut in contractual obligations. We hope to reduce the current deliveries and defer them to the post-1962 period when our purchases will be less than estimated requirements.

Mr. CANNON. Under those circumstances would it not be advantageous to include in the bill language inhibiting or prohibiting contracts providing for delivery, any delivery, prior to 1962?

Mr. MCCONE. You mean new contracts, sir?

Mr. CANNON. New contracts. Of course the contracts you already have are in force, but should we not include in the bill language which will prohibit the letting of contracts for any future delivery prior to 1962?

CONCENTRATE PROCUREMENT POLICY

Mr. JOHNSON. I would like to call to your attention, Mr. Chairman, the policy announced by the Commission in October 1957, which indicated no additional contracts would be made in the pre-1962 period for concentrates. A survey indicated very serious problems. A number had spent substantial sums in the development of uranium deposits and were ready to produce in reliance on the Commission's program. There were public hearings by the joint committee of Congress, and the result was a public release on April 2, 1958, in which the Commission announced a limited expansion of the domestic production. Now all of the contracts that were authorized under this April 2 announcement have not yet been finally negotiated.

Mr. CANNON. Have you asked for bids?

Mr. JOHNSON. They have been under negotiation.

Mr. CANNON. Bids have not been opened and contracts have not been awarded at this time.

Mr. JOHNSON. The contracts have not all been awarded. Most of them have.

Mr. CANNON. Do you have ample concentrates on hand for all foreseeable purposes if we included then a prohibition against delivery prior to 1962, new contracts for delivery prior to 1962?

Mr. JOHNSON. This would mean abrogating or rescinding the——

Mr. CANNON. No, new contracts.

Mr. JOHNSON. These would be new contracts. These would be contracts that were authorized under the April 2, 1958, announcement, but have not yet been executed.

Mr. MCCONE. I think, Mr. Chairman, the wording has recognized the obligation created under the April 2, 1958, limited expansion program which is implemented under this budget and also under the previous budget would be satisfactory and would be consistent with our November 1958 statement withdrawing any further intention to contract. We do feel that the limited expansion program of April 2, 1958, should be carried forward.

Mr. CANNON. However, this program in no way commits the Government to the making of any contract which is not yet in being?

Mr. MCCONE. With the exception of these few contracts that are under negotiation, there is no outstanding arrangement which would commit the Government to enter future contracts in the pre-1962 period.

General LUEDECKE. It should be noted also that the bonus program ends March 31, 1960. So there will be no further bonus.

RESOURCE EVALUATION PROGRAM

Mr. CANNON. Mr. Chairman, tell us something about the resource and evaluation program.

General LUEDECKE. Mr. Johnson will handle that.

Mr. JOHNSON. The resource evaluation program is the program under which our staff studies the various mines, estimates the ore reserves, and obtains the information necessary to carry out, to handle our contracts with the milling companies. It has been essential to survey the ore reserves in connection with the April 2, 1958, announcement. Under the November 24, 1958, announcement whereby the Commission canceled prospectively any obligation to purchase uranium derived from ores to be discovered in the future, and would only purchase concentrate derived from ores discovered prior to November 1958, it is necessary to make extensive surveys of all domestic mines. Our operations cover Wyoming, Utah, Arizona, Colorado, and other States.

Mr. CANNON. Have those surveys been completed?

Mr. JOHNSON. No, sir; they are underway now and we will have to continue to keep a check on where ore is discovered, and from what source ore is shipped under our program.

Mr. CANNON. However, in view of the adequacy of domestic supplies you could curtail your program?

Mr. JOHNSON. That program of course has been drastically reduced over the years and is now only a fraction of the program that we had several years ago.

Mr. CANNON. And may be further reduced?

Mr. JOHNSON. It may be further reduced, but I think it would be undesirable to reduce it to the point where we no longer are obtaining the information regarding the reserves, both present and prospective by not studying and getting information as mining progresses on the various deposits. I think it is important for us to know how much uranium we have.

Mr. KIRWAN. I just left the Deficiency Subcommittee on Appropriations. I would like to quote from that hearing where we were considering a request for an appropriation to cover losses in the purchase of minerals under the Defense Production Act revolving fund.

Mr. KIRWAN. What is the cost of the strategic materials which we have in inventory and on order under all the programs as of December 31, 1958?

How much have we bought?

Mr. FLOETE. Total investments?

Mr. KIRWAN. Yes.

Mr. FLOETE. Total inventories as of March 31 are $8.2 billion.

Mr. KIRWAN. How much of this was required to meet the maximum stockpile objective? In other words, about half?

Mr. FLOETE. Yes, sir.

Mr. KIRWAN. So we have spent over $4 billion that was never necessary to be taken from the American taxpayers.

Now all we hear in America is about the farm surpluses piling up. But there is one thing about the surplus wheat—we can eat it if we ever get into a crisis or have a depression. What will taxpayers say about this $4 billion worth of material we don't need. On top of that, with respect to certain tungsten contracts the grade of the ore was reduced so we purchased millions of dollars worth that was below stockpile grade at prices for in excess of the market price. Now we have to spend millions more to refine it to make it useful for stockpile purposes.

Surely AEC should profit by the costly experience we have had in the purchase of these other minerals. When the domestic tungsten purchase program went into effect in 1951, it was to stabilize the industry. By 1953 the authority was all used up and the act was extended for 2 more years. We bought over $187 million worth of tungsten and all of it was surplus to the stockpile requirement. Then Public Law 733 was passed authorizing the purchase of millions of dollars worth of more tungsten. That is when we refused to appropriate the funds. When this purchase program started, Nevada, a tungsten State, had only three people producing tungsten. But when it was stopped, there were over a hundred producing. They even left Hollywood, bought a couple of scrapers and went on up to Nevada and dug under about 10 feet to sell it to the Government.

Many letters I got came from Hollywood condemning me for not supporting further Government purchases of tungsten when we had already purchased millions of dollars' worth we didn't need. And we have purchased far in excess of our needs in case of many other minerals—over $4 billion in excess of the maximum stockpile objectives—and we are still purchasing because of long-term contract commitments.

This agency that is here this morning should certainly profit from this costly experience and take all necessary steps to assure that we do not make the same mistake under the uranium-purchase program.

Mr. CANNON. The gentleman has emphasized a very important point. We are accumulating vast stockpiles of every possible raw material which might be needed, many of them in excess of what is indicated might be needed in preparation for war, which stockpile will last years, but we are not certain that the next war will last

10 days. Certainly, as Mr. Kirwan says, we are investing a lot of money in the stockpiling of all raw materials. It constitutes one of the important questions before the committee at this time.

COMMISSION POLICY ON STOCKPILING

Mr. McCone. Mr. Chairman, I would like to explain the policy of the Commission. We have no intention whatsoever of stockpiling uranium ore or uranium oxide. In order to stimulate the mining industry at a time when the shortage of uranium was the controlling factor in our production of weapons, we made certain commitments by public announcement, the effect of which was that during certain periods of time we would purchase uranium ore from new discoveries.

Now, when it became apparent to us and particularly to me shortly after I took office that this might lead us, the U.S. Government, into a position where we would have to purchase uranium ore in quantity from new discoveries similar to the situation you mentioned with regard to tungsten, or whatever it was, we took steps to withdraw that public offering. That was withdrawn on November 24, and it has been recognized by the industry. Therefore, we have no obligation whatsoever to buy any uranium at all from any new discoveries after that November 24 date. Prior to that time, the fact that there was an outstanding and publicly announced offer of the U.S. Government to purchase, discoveries and developments prior to November 24 created an obligation on our part to take uranium in accordance with the offering. That is why we withdrew the offer. I think that has stabilized our situation.

Mr. Kirwan. I think it has.

Mr. McCone. Now, this is a difficult thing to do, but we had to do it. Had we not done it, the situation that you envisage would descend upon us. Now, what we must do, however, is to recognize our contractual obligations and those contractual obligations cause us to take a larger amount of uranium in 1960, the fiscal 1960, and 1961 and 1962, than our mills require. After that, our contractual obligations are only a fractional part of our forecasted requirements.

Mr. Cannon. Those contracts have already been executed and are now in being.

Mr. McCone. Those contracts have been executed and are now in being with the exception of the two or three that Mr. Johnson mentioned that were authorized for the April 2, 1958, limited expansion program.

Now we are distressed about having to take one pound more uranium oxide than we need. Therefore, we are going to both our foreign and our domestic suppliers and trying to work out stretchouts so that then we can take some of this uranium oxide in the later years when our contractual commitments in total are far below our forecasted need. This takes the hump out of the supply year.

Mr. Johnson has been quite successful. He indicated that this figure that we are presenting to you is $20 million less than the sum total of our contractual commitment, and we are just gambling that we are going to effect this stretchout.

Mr. Kirwan. You are dealing with a difficult problem, uranium is very essential, but we must guard against long-term contracts that

will require the Government to purchase far in excess of its requirements. Under the Defense Production Act revolving fund, the Government is committed under long-term contracts to purchase over $375 million worth of materials in 1960 and 1961, and all but a very small amount will be excess to our needs. What will we do when the people in the farm belt find out that we are continuing to buy these minerals and already have a surplus of over $4 billion, and yet the farm program is being criticized because of the surplus wheat problem. At least we can eat the wheat if we run into a blight that destroys the crop as it did the chestnut tree, or we have some other crisis causing a scarcity.

Mr. PILLION. I think we are indebted to the gentleman from Ohio for calling this matter to our attention because we want to avoid the surplus situation we have in the mineral stockpile if we can. We certainly don't want that in the uranium field. On the other hand, there is a difference between uranium and other metals which can be sold freely. As I understand, uranium can only be purchased by the U.S. Government. Is that right?

Mr. MCCONE. It is used only by the Government.

URANIUM RESERVES

Mr. PILLION. As I understand, you have 10 years of reserves of uranium in this country and something like 20 in Canada. What is the ideal insofar as years of reserve ahead is concerned? How many years of reserve do you think you ought to have on hand? Have you fixed a policy on that?

Mr. MCCONE. No, we have not fixed a definite policy in the form of a stated Commission position. My personal position is that with a proven reserve of 10 years and with a conjecture on the part of industry that the real figure is more like 20 years—because usually in the mining business, uranium and others, there is more in the mine than is evidenced by the blocked-out proven reserves—I feel quite comfortable; plus the fact that there is a reserve of almost twice that large in Canada which is available to us, because Canada has very little use for it. They sell a little to Great Britain and that is about all. They use a little themselves.

Mr. PILLION. Then you now have enough reserves in your estimation to take care of the foreseeable future?

Mr. MCCONE. That is correct.

Mr. PILLION. Now what happens if I were to go out and invest, say, $100,000, in a discovery or block out of a uranium area, and I had no way of selling it to the public; it could only be sold to the U.S. Government, and I had no way of getting any return on that $100,000. What incentive is there to discover or to explore? In other words, is my investment lost waiting for the Government to come along and say we will need it 12 years from now? In other words, how is a man repaid for investment of his capital for a long-term exploration or obtaining of ore reserves? How is that man compensated?

Mr. MCCONE. He is not compensated under present policy. He would be making such an investment at his own risk. I would imagine

that he would only do so with the recognition that in the post-1962 period it is possible that our demand will exceed our current contract commitments and, if he was successful in the development, he would be able to compete for our business.

Mr. PILLION. You have no policy, then, in which you would say to a man who had a high-grade ore whereby you could take an option on it and pay him, say, 1 percent a year, or some such thing? You have no such policy.

Mr. MCCONE. No, we do not have that at the present time. We do not plan at the moment to make a move to stimulate further exploration and will not do so until our reserves indicate that so doing would be in the interest of the Government.

Mr. PILLION. There is just a general understanding, as I understand it, then, that about a 10-year reserve is about ideal, but there is no fixed policy.

Mr. MCCONE. No, there is no fixed policy.

RESOURCE EVALUATION

Mr. CANNON. In view of what has been said about your program, I note you say in the justification:

* * * this program provides an evaluation of developments in uranium geology and exploration techniques and their application to the appraisal of potential uranium resources and production to relative long-term projects of uranium requirements.

We evidently have adequate supplies of uranium on hand so we need not further emphasize this phase of it, then.

Mr. JOHNSON. No, it is not emphasized, except that that is a by-product of the work that is done in order to carry out the existing program as described before, finding out what uranium deposits are eligible for sale under the current program.

Mr. CANNON. You are asking $2,168,000. You really could get along with around $2 million, could you not?

Mr. JOHNSON. I presume so.

CONCENTRATE PROCUREMENT POLICY

Mr. CANNON. In reference to the release of November 24, it might be well, and I shall include at this point the letter modifying the Atomic Energy Commission uranium concentrates purchasing program filed as of that date. I shall ask the stenographer to include that in the record so that anyone who desires to refer to it will have it at hand.

(The document referred to follows:)

[For release in morning newspapers, Monday, Nov. 24, 1958]

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C.

Note to Editors and Correspondents:

The attached notice modifying the Atomic Energy Commission's 1962–66 uranium concentrate purchase program is being filed today (Monday, November 24, 1958) with the Federal Register.

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C.

The U.S. Atomic Energy Commission: Notice is hereby given of modification of the 1962–66 domestic uranium concentrate procurement program.

1. On May 24, 1956, the Atomic Energy Commission announced that it would guarantee the purchase of U_3O_8 in concentrates produced and delivered during the period April 1, 1962–December 31, 1966. The Commission will carry out its May 24, 1956, commitment with respect to ore reserves developed prior to this date in reliance upon the May 24, 1956, announcement by negotiating for the purchase of appropriate quantities of concentrates derived from such ore reserves during the 1962–66 period. Such purchases will be at the previously established price of $8 per pound for U_3O_8 in an acceptable concentrate.

2. By issuance of this announcement the Atomic Energy Commission hereby withdraws prospectively the concentrate purchase program announced May 24, 1956. With respect to new ore reserves developed after this date, the Commission will make contracts to purchase concentrates to the extent that requirements dictate and on such terms and conditions and at such prices as the Commission may from time to time agree upon. Future programs will give due consideration to the adequacy of domestic ore reserves, the need for exploration and development, the maintenance of the domestic uranium industry, and other factors which way be important to the atomic energy program.

3. The effect of this modification will be to provide the domestic uranium industry with a substantial continuing market for the period 1962–66 for concentrates derived from already developed ore reserves and, at the same time, guard against overproduction.

4. Under this revised program, the Commission's 1962–66 domestic uranium concentrate purchases from ore reserves already developed will be limited to—

(*a*) Current milling contracts;

(*b*) Appropriate extensions of current milling contracts to the extent the Commission determines that the milling facilities are needed for the presently existing mining operations and developed ore reserves;

(*c*) New milling contracts or amendments to existing contracts which may be executed pursuant to the Commission's April 2, 1958, announcement of the limited expansion of the domestic uranium procurement program;

(*d*) New milling contracts or contract amendments which may be negotiated for the purchase of appropriate quantities of concentrates in the 1962–66 period from ore reserves developed between November 1, 1957, and the date hereof.

5. The action taken today is to guard against serious overproduction which might occur under an unlimited purchase program if very large additional uranium discoveries are made. The Commission's action recognizes the need for placing definite limitations on annual deliveries of concentrate and at the same time it gives due consideration to those who already have developed ore reserves in reliance upon the Commission's 1956 announcement. Protection will be given the independent miners by incorporating in all new milling contracts and extensions to existing milling contracts provisions designed to provide independent mine owners a fair share of available milling capacities.

6. Today's action is not due to any forecast of a reduction in the Commission's uranium requirements or in the potential requirements for commercial atomic power. However, it is in the best interest of both the industry and the Government to hold uranium production in reasonable balance with requirements.

For the U.S. Atomic Energy Commission:

PAUL F. FOSTER, *General Manager.*

Dated at Washington, D.C., this 21st day of November 1958.

ALUMINUM PURCHASES

Mr. CANNON. You not only are providing ample supplies of uranium ores and uranium oxide, but, as Mr. Kirwan said, the Government has far more than adequate stockpiles of other raw maerials. How much aluminum does the Commission plan to buy in 1960 for its operations either by indirect purchase or directly?

Mr. MCCARTHY. We are now making a survey to determine what our aluminum requirements are. We made an initial check. We

do not find that we will buy any aluminum in the raw ore stage. It is mostly in the finished product. We are making a check to see what the overall aluminum procurement is. This will mainly be done through our major contractors, of course. We will have to go back to them to see what total is for any given year.

Mr. CANNON. The Government not only has a large excess supply of aluminum, but it is obligated to buy $55.5 million more in 1960 under outstanding contracts. Has the Commission given any thought to purchasing its requirements from GSA to help relieve the excess supply the Government has on hand?

Mr. MCCARTHY. I might say this is under study. The committee staff mentioned this to me a few days ago, Mr. Chairman. We are now looking into it. We hope to see what can be done on it.

Mr. CANNON. It would appear to be practical.

Mr. MCCARTHY. This we do not know as of this moment, Mr. Chairman. We want to make a check with GSA to see what form it is in. The aluminum we use is of high purity which is used in the canning process. We are now looking into this. In recent years the only metal that we have used that we have got from stockpile is the use of mercury of which the stockpile had a large content which we could not buy in the open market and which we did use, and bought from the stockpile. We are now looking at that and discussing it with GSA on the aluminum and I believe the staff also mentioned cobalt and two or three other items.

Mr. CANNON. It would be quite helpful if we could have it in before we mark up the bill. I wonder if you could hurry that matter a little bit and get us some information within the next few days.

Mr. MCCARTHY. We will make every attempt to do so.

Mr. CANNON. We will appreciate it if you can do that.

(The matter referred to follows:)

ATOMIC ENERGY COMMISSION,
Washington, D.C., July 8, 1959.

HON. CLARENCE CANNON,
Chairman, Committee on Appropriations,
House of Representatives.

DEAR MR. CANNON: During the course of the recently completed hearings before your committee on the Commission's fiscal year 1960 budget estimates, the Commission was requested to study the feasibility of procuring from GSA certain materials which are being stockpiled such as aluminum and copper, which are in excess of the stockpile goals, and to report back to your committee the results of this study.

In this connection GSA was contacted to ascertain in what form these excess materials were available in order to determine their suitability in meeting AEC needs. We were advised that the material in stockpile is in a fairly basic form, i.e. pigs, ingots or their equivalent. It should be noted that AEC requirements for material in this particular form are relatively minor, the bulk of our needs being for finished fabricated or semifabricated shapes. For example, available AEC requirements data covering aluminum and aluminum-base alloys indicate that the AEC program will use only 4 percent of its total 1960 requirements of approximately 16,303,000 pounds in the form of aluminum pigs or ingots. This 4 percent or approximately 650,000 pounds would have a dollar value of about $165,000 at current prices, exclusive of transportation and handling costs. In the case of copper and copper-base alloys, the AEC requirements are almost entirely composed of various finished brass-mill and wire-mill products.

In view of the foregoing, for the Atomic Energy Commission to meet any of its materials requirements through use of excess stockpile materials, it would be necessary to make a major change in its current procurement procedures.

Generally, at present, the Commissions' cost-type operating contractors go out to suppliers on a competitive bid basis for the procurement of finished fabricated and semifabricated articles made of the materials under discussion. These suppliers of course are, in many instances, dependent upon a more primary supplier for the raw stocks, which in turn they convert into the forms called for by the AEC operating contractors in their bid invitations. Therefore, if the Commission is to use excess stockpile materials the following would be required:

(1) Proper authorization would have to be received to have excess U.S. national stockpile stocks made available to AEC. We have been advised that this requires congressional approval;[1]

(2) The AEC would have to pay current market prices for this material;

(3) The AEC operating contractors, in their bid invitations would have to specify that the raw stocks would be Government-furnished materials, and that bid amounts must be based on conversion costs only;

(4) The AEC would have to assure that the materials would get from the stockpile locations into the hands of the successful supply bidders and pay any necessary costs.

Within the limited time available, it has been possible to assess only the highlights of the problems, as outlined above, associated with the Commission utilizing excess stockpile materials. We shall be pleased to work further with your staff in detailing the administrative problems involved as well as discussing what authorizations by Congress and the executive branch would be required if such a procedure were to be placed in effect.

Sincerely yours,

A. R. LUEDECKE, *General Manager.*

WORLD URANIUM ORE RESERVES

Mr. MAGNUSON. Mr. Johnson, I think in your general statement you mentioned reserves of 80 million tons?

Mr. JOHNSON. Yes, sir.

Mr. MAGNUSON. Is that ore or concentrate?

Mr. JOHNSON. That is ore.

Mr. MAGNUSON. Is that in the United States or in the free world?

Mr. JOHNSON. The 80 million tons is the U.S. reserve which represents approximately 200,000 tons of uranium oxide.

Mr. MAGNUSON. What do you know about the reserve behind the Iron Curtain?

Mr. JOHNSON. We have very little information unless our intelligence people have, and that has not been made available to me. We do know in the early period Russia used every effort possible to get enough uranium for its program because of the operations of the deposits in Czechoslovakia where thousands of slave laborers were used. I think that information was clear, because operations were across the border of the Iron Curtain.

Undoubtedly with the effort that Russia has put on uranium exploration they have turned up deposits in their vast hinterlands. How much I have no information.

Mr. MAGNUSON. Our scientists and geologists must know something about the geology of that country.

Mr. JOHNSON. I can only state it this way. There are large areas of Russia on which we have pre-Soviet general information on the geology that indicates good hunting grounds.

Mr. MAGNUSON. That is all.

Mr. CANNON. Mr. Jensen.

Mr. JENSEN. Off the record.

(Discussion off the record.)

[1] CLERK'S NOTE.—No special approval is required to transfer excess materials from the Defense Production Act inventory to agencies of the Federal Government. Reference in letter is to U.S. national stockpile.

Mr. CANNON. Back on the record.

STOCKPILING OF MATERIALS

Mr. JENSEN. Now, the Commission has stockpiled concentrates, uranium, and many other materials. Just what does your stockpile contain today of the different kinds of material that is necessary for war and peace?

Mr. MCCONE. We can give you for the record a report of our inventory of materials in their various stages. However, as a matter of policy, we are not stockpiling any materials because we are buying our requirements as current as possible.

Mr. JENSEN. Now, we hear an awful lot about the Government buying all these minerals and metals which they need for military purposes, and we have these great stockpiles of these strategic materials. Just where are they? I would like to know.

Mr. MCCONE. The responsibility for the acquisition and custodial problems of the stockpile are the General Services Administration and the Office of Civilian Defense Mobilization.

Mr. JENSEN. That is right. Now, since the stockpile question has arisen here, and I think properly, I think this committee is entitled to know accurately just how much of these strategic materials we have in the stockpile above the ground, whether they are in the hands of the Government or in the hands of private industry. I think we should have that information.

Mr. MAGNUSON. Will the gentleman yield?

Mr. JENSEN. Yes.

Mr. MAGNUSON. It seems to me that the Atomic Energy Commission has no responsibility for any of these metals except uranium. Are you directing the question to the proper agency?

Mr. JENSEN. I understand, but this committee has the responsibility to see to it that we have sufficient stockpiles of the strategic war materials and we have responsibility of seeing to it that we do not waste the money in the purchase of such things as well as other things, that we do not need.

Mr. KIRWAN. Will the gentleman yield there?

Mr. JENSEN. Yes.

Mr. KIRWAN. We have this responsibility. We may not know how to get rid of the farm products, but surely we ought to know how to sell our own agency of the Government what we have in the stockpile without going out and buying any more. Is that what you mean?

Mr. JENSEN. You are absolutely right.

Mr. KIRWAN. Surely we ought to be able among ourselves to cut that stockpile down among the different agencies.

Mr. JENSEN. Of course, we know that the General Services Administration and the Office of Civil and Defense Mobilization come under the jurisdiction of Mr. Thomas' committee, the Independent Offices Subcommittee on Appropriations. AEC materials are supposed to be in the pipeline now or in the finished product. However, you have no actual stockpile of raw material in your program, is that right?

Mr. MCCONE. That is correct.

Mr. JENSEN. But if there is a great stockpile of these materials in the supply of General Services, which the AEC uses and must have

then certainly the AEC should be purchasing from those stockpiles. What purpose could be more important than that for which you are responsible.

Now, the matter that Mr. Kirwan has spoken to concerns all of us. Of course we are told that there is about $50 billion worth of obsolete military equipment in storage here and all over the world. As Mr. Kirwan has said, there is a hue and cry about the $8 billion farm products that are in Government storage, but very little is said about the many times that figure that is in Government storehouses, purchased by taxpayers' money, in military supplies, most of it in obsolete supplies which is just lying around. I contend there is not much effort being made to dispose of that obsolete material. That is not your responsibility, however.

PROHIBITION AGAINST ENTERING INTO ADDITIONAL CONTRACTS FOR PURCHASE OF URANIUM

Now, Mr. Cannon, if prohibitive language is to be inserted in the bill or in the report relative to this matter of not entering into other contracts for the purchase of uranium, without a doubt that wording is going to have to be pretty carefully drawn. If the committee decides to put such language in the bill or in the report, the Commission and our committee staff and possibly you, Mr. Chairman, should collaborate in writing such language, because you would not want that language to be anything but 100 percent right. That is a suggestion. I can see where we could put language in the bill that if not properly drawn might be detrimental to the program of the Atomic Energy Commission. It is a great responsibility which you gentlemen have. I know that the committee does not want to tie your hands in any way, shape, or form, but we would want to do our level best not to waste the money and to have more uranium oxide than the Commission needs.

Mr. CANNON. Dr. Fenton.

LOCALE OF URANIUM ORES

Dr. FENTON. I am very much interested in Dr. Johnson's testimony as to the areas in this country from which we are getting uranium. How about Pennsylvania, sir? I know they have done some work there.

Mr. JOHNSON. There was a small deposit found near Mauch Chunk, Pa., but a matter of only a few thousand tons of ore was developed at that time. There was quite extensive geological investigation in Pennsylvania and considerable private prospecting, but the results were not productive.

Dr. FENTON. I am familiar with that terrain.

Mr. JOHNSON. The western mines range from surface mines up to a thousand feet in depth.

Dr. FENTON. Are vanadium and thorium more or less byproducts of uranium?

VANADIUM

Mr. JOHNSON. No, sir. Vanadium is a byproduct. Thorium has not been. The material that we are purchasing, and we have only

a small remaining contract that will be completed this coming fiscal year, is produced from monazite sands.

Dr. FENTON. What does the Commission use vanadium for principally?

Mr. JOHNSON. We are not using vanadium. The reason that we have vanadium procurement was that the only ores known in this country when the program started, and these ores were the principal source of our domestic uranium for a number of years, were the uranium-vanadium ores of the Colorado Plateau. The ore as mined contains both vanadium and uranium. Under some of our older contracts the Commission has an obligation to purchase the vanadium that is surplus to the commercial market. Our obligations are declining, and there will be no obligations for vanadium after March 31, 1962. Even before 1962 our commitments for vanadium will be relatively small. In the past we have paid up to $7 million or more a year for vanadium. This year the vanadium purchases will be on the order of $2.5 million, and they will be lower each succeeding year, and all commitments expire by March 31, 1962.

FOREIGN EXPLORATION PROGRAM

Dr. FENTON. In our technical assistance program that you people have, how many foreign countries do you cooperate with?

Mr. JOHNSON. At the present time we have one or two geologists in Peru, Chile, and Brazil. We have made a number of spot examinations in a large number of countries, particularly during the earlier period of our program when we were short of uranium and we were looking for new sources wherever they might be found. We have continued to give technical assistance to representatives of friendly countries coming to this country who wanted to learn about the methods of exploration for uranium and processing. We have a number of visitors each year. I would expect that the programs where we have stationed geologists in foreign countries might be terminated at an early date.

Dr. FENTON. This has nothing to do with our mutual assistance program.

Mr. JOHNSON. No.

PURCHASE PRICE OF ORES

Dr. FENTON. On procurement of uranium, I notice that in 1958 you paid $35.90 a ton, in 1959, $34.68 a ton. For 1960 you are going up to $37.49. What is the explanation for that variation?

Mr. JOHNSON. These figures relate to the uranium ore which has been purchased by the Commission and the variations in price is due to the variation in the grade of the ore. All of the ore in 1958, 1959, 1960, is purchased on the basis of the price schedule in circular 5, which was issued in February of 1951. The circular expires on March 31, 1962. More than 95 percent of the ore produced in this country is sold directly to the mills and does not go through the hands of the Commission, but the figures that you see here are those for the ore which was purchased by the Commission.

Dr. FENTON. Crude ore?

Mr. JOHNSON. Crude ore, yes.

Dr. FENTON. You pay the mills a certain amount for refining?

Mr. JOHNSON. Most of the procurement is based upon unit prices for the concentrated product that is sold to the Commission by the mills. That includes the ore prices as well. In the case of our ore stockpiles, generally these have been and are being sold to the mills at our inbound cost, and there is a credit for the ore sales shown in the budget.

Dr. FENTON. I think that is all, Mr. Chairman. Thank you.

Mr. CANNON. The gentleman from Minnesota.

Mr. ANDERSON. Mr. Cannon, I have just one question. I presume that is what you would like now, a general question?

Mr. CANNON. We are on raw material now.

THORIUM

Mr. PILLION. Are we stockpiling thorium?

Mr. JOHNSON. Yes, sir. We have a limited stockpile objective of about 2,000 tons, and that stockpile goal will be reached with the completion of the last contract in fiscal 1960. This material is for experimental and developmental purposes.

Mr. PILLION. Do you carry a military stockpile over and above the stockpile that you are building?

Mr. JOHNSON. Not to my knowledge.

Mr. PILLION. Does anyone here have any knowledge different than that?

In the report that the chairman asked for with respect to the possibility of purchasing some materials from General Services Administration, I wondered if you could have a statement there of the law with respect to that, the availability of the material in General Services and military stockpiles, and what problems there might be with relation to purchasing from the excess over and above the military requirements, instead of buying on the open market. I presume that would include metals such as aluminum or mercury. Are there other metals such as zirconium that are being bought now in the open market other than uranium? Does anyone have the metal purchases by the Commission?

General LUEDECKE. Zirconium.

Mr. PILLION. Does the military stockpile that?

General LUEDECKE. Not to my knowledge.

Mr. PILLION. Is there any military stockpiling of the others?

Mr. MCCARTHY. This is one thing we are looking into in terms of the GSA.

Mr. PILLION. I am quite surprised at the poor quality relatively of the Canadian ore. I thought that strike up in Great Bear Lake was quite a rich strike. I see from the reports here that the uranium content of the Canadian ores is only half of that of the United States. Is that right?

Mr. JOHNSON. That is right. The Great Bear Lake mine was an important source of uranium in the early period. There was high-grade production in that mine, but the average grade produced today is only slightly higher than our domestic grade. The major production in Canada is now from the Blind River field and Bancroft area, not far from the border. That ore contains about 2 pounds of uranium oxide per ton, as compared with 5 pounds for average grade domestic ore.

Mr. PILLION. To follow up on the questions that the gentleman from Pennsylvania asked, are we giving technical assistance in this field or in the reactor field to countries like Poland or Yugoslavia?

Mr. JOHNSON. Not in the raw materials field.

EXCHANGE OF INFORMATION THROUGH IAEA

Mr. PILLION. Any other field, the nuclear reactors field, for instance?

Mr. MCCONE. Yes. There is an exchange of information on reactors through the International Atomic Energy Agency.

Mr. PILLION. Is that the atoms for peace program?

Mr. MCCONE. Yes. As you know, there is an International Atomic Energy Agency which was a special agency under the United Nations, headquarters in Vienna. I believe it has 70 members, governed by a Board of Governors, on which the United States is represented along with 22 other countries, and staffed, and it provides facilities for the exchange of technical information.

Mr. PILLION. We give a great deal of information to that Agency, I presume.

Mr. MCCONE. I think so.

Mr. PILLION. How much do we get from Russia?

Mr. MCCONE. Not very much.

Mr. PILLION. How much do we get from Poland or Yugoslavia?

Mr. MCCONE. I think very little. I will say, however, that the Agency that was established a year ago last September is really only now reaching the point where it is becoming effective. We have hopes that there will be some exchanges of information.

Mr. PILLION. I do not give very much credence to hopes in dealing with the Iron Curtain countries. How can we relate the information that we give to the reciprocal amount of information given to us by countries like the Soviet? In other words, suppose we say we are not going to give information unless we get some information coming in to us from behind the Iron Curtain. Do we have a policy concerning that?

Mr. MCCONE. In the unclassified fields of the peaceful development of the atom, the information is all made public. It is all published in books, in technical magazines and papers issued by the Commission or its contractors, private industry, that is financing and promoting these developments. Whether that information is exchanged or translated to them through the Agency or they pick it up by purchasing the journals, it is there. There is no attempt whatsoever to classify it.

Mr. PILLION. If all we give is material that is public to everyone and they can pick it up anywhere, then what is the purpose of having an Atoms for Peace organization within the United Nations? Why are we spending millions of dollars to keep that going?

Mr. MCCONE. There seems to be a useful purpose in the exchange of information and most particularly in the lesser developed countries where, by exchanging information and education in a variety of fields, not the least important of which is medicine and agriculture, it serves a purpose. Furthermore, the central reason for this Agency is for the safety problems that will develop as reactors are built in various countries throughout the world because those reactors must be built really to international standards. The radioactive consequences of an acci-

dent recognize no international boundary. What happens to a reactor in Belgium could be of serious consequence to a neighboring country. It is the hope and it is my firm belief that the International Agency will prove to be the one agency through which problems of that kind will be resolved.

Mr. PILLION. I question the extent to which this country should feed to the United Nations our information, whether classified or unclassified. It makes it that much easier for them to get, without return of information from the Iron Curtain countries. I don't know the answer to it, of course. I am just expressing a feeling about the situation.

Mr. MCCONE. The Iron Curtain countries do release a great deal of information in the same area, and there have been frequent exchanges. I cannot place my finger on a particularly useful gain from them. As you know, they had a very extensive exhibit and substantial presentations at Geneva a year ago. This has been of some value and this type of collaboration on the scientific level is continuing.

Like you, I am concerned about working on one-way streets in this area, but since this information is available through normal channels, there is no special access developed through the agency.

Mr. PILLION. Thank you very much.

Mr. EVINS (presiding). The gentleman from New York is a very patriotic American. As a member of this committee he had the same impression that I had a year ago on this particular subject. I gained the impression that we were giving libraries of information to some foreign nations of the world and we were unable to determine what we were receiving in exchange. Over the years this exchange program has been going on. Can you point a finger to one thing of value that we have received from any source?

Mr. MCCONE. Yes. We have gotten a considerable amount of information from the British on that gas-cooled reactor program and their development work there. Furthermore, in a more classified field, the exchange of weapons information with the British, which was provided by last year's legislation, and the implementing bilateral treaty has been very useful to us.

Mr. EVINS. It seems very essential and very important to continue this, but I have been uncertain in my own mind what we are receiving quid pro quo for the information that we were giving. We are a great, generous nation. We are the Nation that developed the bomb. We gained scientific information, and we disseminate it freely all over the world through libraries and also three or four traveling exhibits to give further information abroad.

DOMESTIC EXHIBIT PROGRAM

How is our exhibit program coming along that we appropriated for a few years ago? Where are they located, and how many are there, and what has been the participation? What has been the interest?

Mr. SALISBURY. The domestic program has two traveling exhibits of full size, 7,000 square feet, and five programs of exhibits in large vans, and six exhibits for schools around the country. Now they have reached all the States. As to the exhibit program on the inter-

national side, that is not in charge of the outfit that I happen to be in charge of.

Mr. EVINS. That is not related to the materials program?

Mr. SALISBURY. No.

Mr. EVINS. I think that concludes, Mr. Chairman, all on the materials program.

SPECIAL NUCLEAR MATERIALS

Mr. CANNON. Taking up the estimate for special nuclear materials for which you ask $568 million, I shall ask the stenographer to include pages 26 and 27 here.

(The information follows:)

SPECIAL NUCLEAR MATERIALS PROGRAM—OPERATING COSTS

Program statement

Estimate fiscal year 1960	$568,000,000
Estimate fiscal year 1959	545,000,000
Increase	23,000,000

Summary of estimates by category

Category	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
1. Procurement and production	$531,102,410	$506,525,000	$531,100,000
2. Process development	36,583,673	38,475,000	36,900,000
Total special nuclear materials program	567,686,083	545,000,000	568,000,000

JUSTIFICATION OF CATEGORIES

1. Procurement and production, $531,100,000

These funds provide for the operation of Government facilities for the production of special nuclear and other special materials required for use in weapons manufacture, research and development, and in the peaceful applications of atomic energy. The major units of the production complex are located at Oak Ridge, Tenn., Paducas, Ky., Portsmouth, Ohio, Hanford, Wash., Savannah River, S.C., Fernald, Ohio, and Weldon Spring, Mo. Although there is an increase in materials to be processed the increase in cost is moderate, since unit costs of processing have declined in most of the steps in the production chain.

2. Process development, $36,900,000

These funds provide for technical plant support assuring continuity and safety of operations, and development and improvement of processes and equipment utilized in producing and processing unanium feed materials, enriched U^{235}, plutonium, and other special products. The development program also assures attainment of production levels required to meet current AEC commitments at the lowest possible cost of operation. Development effort varies at each site in accordance with the production requirements of the sites.

Mr. CANNON. The unit cost of hexafluoride has increased sharply. How do you account for the increase?

General LUEDECKE. Mr. Bloch will answer that question.

Mr. BLOCH. Mr. Chairman, the unit cost reflects the first full year of operation of a new, privately owned plant which is processing annually 4,200 tons of uranium. So this reflects the cost of bringing another plant into the production of this material.

Mr. CANNON. That would seem a good reason why you should not bring another plant into production. Heretofore, in many of your

operations, you have accommodated yourself. Why would it not be more advantageous for you to handle this work yourself? When you contract it, not only do you have to pay the increased cost, but the processors have an incentive to extend the program as may prove to their best interest, regardless of the interest of the Commission. Why would it not be advisable to do it yourself?

Mr. BLOCH. Mr. Chairman, as I believe I indicated last year, several years ago we needed to get additional processing capacity. At that time we secured an appropraition of $22 million with which we could either build a plant ourselves or alternatively use a portion of that money to underwrite a commercial operator to produce this same material in the event we could get good proposals.

Mr. CANNON. In other words, you furnish the other fellow the capital and then you also give a contract when you could have gone ahead, yourself, and done the work more quickly and at least as effectively and certainly cheaper.

Mr. BLOCH. Mr. Chairman, we have not furnished any capital. This is a unit-price contract. It was based on competitive bids, and the bid that we got compared favorably with our estimate of doing the job, ourselves. By doing that——

Mr. CANNON. You tell us here that it cost more. The committee does not look upon that as favorable.

Mr. BLOCH. Sir, the unit price from the supplier includes his operating cost and something for the amortization of his plant, whereas the unit processing cost from our own plant as reflected in this budget is merely our out-of-pocket cost. That is, our unit cost of processing as shown in this budget does not reflect the investment that the government has made in the capital facilities.

Mr. CANNON. I suppose that would be impractical in view of the fact of what becomes involved here, and you advertise for bids and get competitive bids?

Mr. BLOCH. This contract was awarded as a result of competitive bids.

Mr. CANNON. How many bids did you have?

Mr. BLOCH. We received seven bids.

Mr. CANNON. This is the lowest of all of them?

Mr. BLOCH. Yes, sir.

CASCADE POWER

Mr. CANNON. The unit cost of power for Paducah has increased, but it has not increased at Oak Ridge. Why can't you do the work up at Paducah and Portsmouth as economically as you do it down at Oak Ridge?

Mr. BLOCH. Mr. Chairman, we get our power for all three of these plants under long term power contracts that run for upwards of 25 years. Now, these contracts, some of which are with TVA, have provisions for escalation based on the actual cost of fuel. The reason that Oak Ridge has remained constant is that the fuel cost down there, the cost of coal in that area to which the escalation is tied, has remained more stable than the cost of coal in the other areas that are being drawn on for the Paducah and Portsmouth operation. Any long term power contract would contain this provision for escalation in fuel cost.

Mr. CANNON. You utilize no fuel except coal?

Mr. BLOCH. We buy power delivered to these plants from TVA and EEI, and Ohio Valley Electric Corp., but under the contracts our price for power is based upon a fuel cost.

Mr. CANNON. Is there provision for both propane gas and oil?

Mr. BLOCH. It is coal, sir.

Mr. CANNON. Is coal the most economical or practical?

Mr. BLOCH. Coal is very much cheaper. One of the reasons for locating these diffusion plants in these areas was the fact that coal costs, and hence our power costs, were quite cheap.

Mr. ANDERSEN. What is the cost of a ton of coal, say 14,000 B.t.u. coal, to that particular company that you mentioned, the Ohio Valley Electric Co.? What do they pay for coal there?

Mr. BLOCH. I think I have some current figures.

Mr. ANDERSEN. Presumably it is a good grade of bituminous coal?

Mr. BLOCH. I believe Ohio Valley Electric Corp. coal for one of its plants, is running about $4.29 a ton. For the other plant, which is in Ohio, the cost is running about $5.78 per ton.

Mr. ANDERSEN. That is a very reasonable price, is it not?

Mr. BLOCH. Yes, sir.

Mr. CANNON. Well, the significant thing here is that Oak Ridge is in the TVA trade area. The price is stabilized. But when you get outside of the TVA territory, then the price of power goes up. That would seem to be a very strong recommendation for TVA. They are still supplying power at the old rate. Can you tell us where the cost of power is increasing?

Mr. BLOCH. Mr. Chairman, these estimates of power cost reflect some escalation in the case of TVA as well as in the case of the other suppliers. The TVA contracts contain escalation provisions on fuel and TVA supplies about 60 percent of the power at our Paducah plant. So there is some projected increase in power cost there from both TVA and also Electric Energy, Inc., tied to the cost of fuel.

Mr. CANNON. But the TVA has not increased its rate, has it?

Mr. BLOCH. No, sir. All these long term contracts are based on a fixed base rate plus the escalation that I mentioned on fuel to which you have to be subject in that contract.

Mr. CANNON. Does power produced by TVA compare favorably in price with power produced elsewhere in the United States?

Mr. BLOCH. Yes.

Mr. ANDERSEN. What do you pay for coal at Hanford?

Mr. BLOCH. I will have to supply that for the record. I think offhand that it probably would run about $7 or $8 or thereabouts for 11,000 or 12,000 B.t.u., but I will supply that for the record.

(The information follows:)

Awards for steam coal, fiscal year 1959—Handford Works, Richland, Wash.

Supplier	As received B.t.u. per pound	Delivered price per ton
Carbon Fuel Co	13,008	$9.40
Kemmerer Coal Co	10,104	7.32
Mountain States Mining Co	9,882	7.06

Mr. CANNON. Mr. Pillion.

Mr. PILLION. I wonder if we might have for the record a listing of the larger power uses in your larger plants with the rates of each of the producers of British thermal units so that we might have a comparative situation.

Mr. BLOCH. We will do that, sir.

(The information referred to follows:)

Electric power operating experience at major production installations

	Demand (megawatts)	Consumption (million kilowatt-hours)	Power costs [1]		Fuel costs			Supplier
			Total (millions)	Mills per kilowatt-hours	Cents per million B.t.u.	B.t.u. per pound	Dollars per ton	
Hanford, Wash	320	2,400	$5.5	2.29	[2]	[2]	[2]	Bonneville Power Administration.
Oak Ridge, Tenn	700	6,175	22.0	3.57	[3] 19.18	[3] 12,200	[3] 4.68	Tennessee Valley Authority.
	1,220	10,674	42.7	4.00	[4] 18.92	[4] 12,000	[4] 4.54	Do.
	200	1,747	7.4	4.25	18.40	12,500	4.60	K–25 steamplant.
Paducah, Ky	1,205	10,525	38.8	3.67	16.33	11,000	3.59	Tennessee Valley Authority.
	735	6,406	24.7	3.85	18.67	12,015	4.49	Electric Energy, Inc.
Portsmouth, Ohio	1,950	17,103	68.6	4.01	23.50	12,328	[5] 5.78	Ohio Valley Electric Corp.
					19.60	10,926	[6] 4.29	Do.
Savannah River, S.C.	95	700	4.3	6.21	32.56	[7]	[7]	South Carolina Electric & Gas Co.
	160	1,000	6.3	6.33	30.19	13,000	8.16	Self-generation.

[1] Actual fiscal year 1959 power cost experience at the using site.
[2] Hydroelectric generation.
[3] Fuel costs for Watts Bar, Widows Creek, and Kingston plants.
[4] Fuel costs for all plants except Shawnee.
[5] Fuel costs for Kyger Creek, Ohio, plant.
[6] Fuel costs for Clifty Creek, Ind., plant.
[7] Composite system using oil, gas, and coal.

EQUIPMENT

Mr. CANNON. Your equipment item also continues to increase. Why aren't you able to stabilize equipment costs?

Mr. BLOCH. We are projecting a slight increase in 1960 primarily for additional equipment that we will need in connection with the new production reactor that is being built at Hanford. There is considerable development work related to this production reactor that will require some equipment. Now, in addition, of course, this projection of our equipment requirements represents our best estimate based on experience of what the complex of production plants will need in order to keep them operating efficiently.

Mr. CANNON. Your equipment costs this year are estimated to be $23,507,000. Would it seem at all likely you could level that off and make it $23 million?

Mr. BLOCH. Yes, sir; I could not estimate closer than that.

Mr. CANNON. We don't like these odd figures here. Mr. Chairman, that would be all right if we made it $23 million.

Mr. MCCONE. We have brought that figure down from the original request, Mr. Chairman. I could not say that the reduction of $507,000 would seriously cripple the program. It has been rather carefully reviewed by the staff and the Commission as well. I do point out that

we have a large complex of facilities to maintain and that it does require equipment to do it. It is an item that we are continually fighting, but there seems to be demand at every turn, unfortunately.

ESTIMATES AND ACTUAL COSTS

Mr. CANNON. This program in times past has underrun the estimate by sizable amounts, especially in the last 2 or 3 years. I shall be glad if you will put in the record another tabulation showing estimates and actual cost, and the differences between estimates and the cost, for each of the last 5 years. Of course, you might include the current list of 1959.

(The information referred to follows:)

Special nuclear materials program—Comparison of congressional submission with actual or estimated cost experience

[In millions of dollars]

	Congressional submission	Actual cost	Difference
Fiscal year:			
1956	629.1	553.1	−76.0
1957	604.8	581.6	−23.2
1958	594.3	567.7	−26.6
		Present estimated cost	
1959	580.4	545.0	−35.4
	President's budget	Revised budget [1] (H. Doc. 179)	
1960	581.0	568.0	−13.0

[1] The $13,000,000 reduction from the President's budget is due to program requirement changes and reductions based on actual fiscal year 1959 cost experience through April 1959.

NOTE.—Data for fiscal year 1955 is classified; however, the costs were $99,100,000 below the estimate for that year.

Mr. CANNON. Are there any further questions on special nuclear materials?

Mr. EVINS. No questions, Mr. Chairman.

Dr. FENTON. I have one question.

Mr. CANNON. Dr. Fenton.

PROCESS DEVELOPMENT

Dr. FENTON. Do the economies in operation resulting from this program justify the expenditures up to date?

Mr. BLOCH. Yes, sir, many times over. By carrying on a development program, we have been able to modernize our plants and get maximum use out of them. We are producing more material from these plants than was originally estimated, and we are doing it cheaper. For example, our development work has resulted in our improving the gaseous diffusion cascades, and this improvement and

modernization has yielded an increase in efficiency. So we feel this program has really paid its way many times over.

Mr. McCone. I would like to comment on that, if I could, Mr. Chairman.

I have observed the operation of the cascades at Oak Ridge as they are now as compared with the operations when I was here as Under Secretary of the Air Force several years ago. It is my opinion that the moneys which have been spent on this cascade improvement program which is now partially completed but not wholly completed is one of the most remunerative expenditures in the way of payback that we have made.

Turning to the matter of plutonium at Hanford, through the past year we have developed a means of increasing the power level.

Dr. Fenton. Are there any further potentials?

Mr. McCone. The cascade improvement will continue. I think there are 2 or 3 years more on that program.

Mr. Bloch. Yes, at least. New developments are coming along that look promising. We see further potential in the reactors from the results both at Hanford and Savannah River.

Weapons

Mr. Cannon. Passing on to the weapons program, there is an estimate of $495 million. We shall insert page 41 in the record.

(The information follows:)

Weapons Program—Operating Costs

Program statement

Estimate fiscal year 1960	$495,000,000
Estimate fiscal year 1959	480,000,000
Increase	+15,000,000

The amount requested for fiscal year 1960 reflects the estimate of funds needed for the development, production, storage and surveillance of atomic weapons required to meet military needs.

Atomic research has continued to yield new information applicable to development of weapons and such data will be incorporated in the design of new models which will greatly enhance the capabilities of the Armed Forces.

Possible limit to weapons stockpile

Mr. Cannon. Do you think, Mr. Chairman, that the material now stored for weapons would be adequate? You tell us that the material does not deteriorate. How rapidly are we approaching that period?

Mr. McCone. Not very rapidly sir. While it is true that we are using the material in the obsolete weapons, refabricating it into the newer designs, there are a great many new weapons systems being introduced that call for nuclear weapons. I mentioned some of them yesterday. This calls for continual production of both uranium 235 and plutonium and the use of that material in the manufacture of these new weapons in addition to the refabricating of the obsolete weapons.

Mr. Cannon. In the meantime we are continuing to add to our bomb stockpile and we are being told in the newspapers, however ac-

curate news reports may be—it is surprising how efficient they are in prying information out of members of the committee, of course, I don't suppose they ever get any from the departments—that only a certain number of them could be used in a given period of time without jeopardizing our own safety and that of the rest of the peaceful world? If that is true, if we can only use a certain amount without jeopardizing the life of this generation and the coming generations, when we reach that level in our stockpile would it be advisable to stop? Why should we continue to pile up a reserve which cannot be used without incredible danger to all mankind?

Mr. McCone. The representatives of the Department of Defense could better answer the question regarding our future requirements than could spokesmen for the Atomic Energy Commission.

Mr. Cannon. You work in very close relations with them. I believe you told us at the beginning of the hearing that you were in close touch with the Department and you are collaborating with them.

Mr. McCone. That is right. With respect to the first part of your question, your conjecture of the possibility that a nuclear war might create an environment in which mankind could not exist, growing out of the Neville Shute book, "On the Beach," a year or two ago, the studies that have been conducted recently have indicated that despite——

Mr. Cannon. Off the record.

(Discussion off the record.)

Mr. McCone. Despite the effects of the nuclear war on the countries that are involved and the less serious but still serious effects on the countries immediately adjoining them, the balance of the world would not be disastrously affected.

Mr. Cannon. Only the combatants would be disastrously affected?

Mr. McCone. The combatant countries would be disastrously affected. The countries immediately adjoining would be affected seriously but the distant countries would not be affected seriously.

Mr. Cannon. In that event, we might wind up with a world population limited to the inhabitants of Tibet.

Mr. McCone. Yes, and the South Americans might get along all right. You could imagine a situation like that.

Mr. Cannon. Well, that is a practical question. If there is a limit, and scientists tell us there is a limit beyond which we cannot go without destruction, why should we not determine where that line of demarcation is and stop there?

Mr. McCone. I think that is a very good question, sir. I would think if we were building a stockpile for a single purpose, such as strategic counteroffensive, there would be a limit——

Mr. Cannon. You are distinguishing there between the purpose of stockpiles for war and stockpiles for industry?

Mr. McCone. No, I am talking about the war. Now, if you are building for a single purpose, such as the strategic counteroffensive, there would be a limit, and you would say that limit would be probably enough. Maybe some military planners would not agree, but it would be my opinion that you would reach that point. However, we find as weapons become smaller and different configurations they are useful in a variety of ways, i.e., for air defense, air-to-air vessels, tacti-

cal weapons for the ground forces, antisubmarines, and so forth. As a consequence, the requirements are shifting now, so you are meeting the needs of these various weapons systems.

Mr. CANNON. Now we are dealing with a very specialized subject, Mr. Chairman. We are dealing here with the weapons program. We are not dealing with any peacetime utilization whatever. If you limit this to bombs, the accumulation of stockpiles for enemy destruction, isn't there a limit of reserves beyond which we need not go because to go beyond that limit would be to produce a supply of bombs which cannot be used without certain destruction? What about that?

Mr. MCCONE. Yes, I would think there would be a limit.

Mr. CANNON. Have you in your cooperation with the national defense, the Defense Department, discussed that limit?

Mr. MCCONE. No, we have discussed their future requirements. We have their specific future requirements for the next 4 years.

Mr. CANNON. I don't know that it would be a matter of requirement. It would be a matter of toleration. It would be a matter of how much we could detonate without injury to the human race. Now, the newspapers are full and, as I say, our committees are all studying just how destructive they are, and in what way they are injurious. Now, do you produce more for our stockpile or our reserves than we dare use?

Mr. MCCONE. I do not think that that is a situation that we are approaching. Perhaps General Starbird, who is much closer to the actual planning figures than I am, could comment on that.

Mr. CANNON. I would like to ask one question. Do we at this time have more bombs than we could safely detonate in a month? In a week? In a day?

General STARBIRD. Considering what we believe could be delivered, I believe the answer is "No."

Mr. CANNON. We have not reached a point where we could at this time explode everything we have in stock, being everything we have in reserve, and still it would not be sufficient to imperil the race?

General STARBIRD. I said considering what we could expect to deliver.

Mr. CANNON. I do not quite understand what you expect to deliver. You would be able to delivery everything you have in the stockpile?

General STARBIRD. Our basic philosophy is one that we do not intend to attack. This is a philosophy of our people.

Mr. CANNON. We are not discussing that question now. We are discussing how many we dare to explode at this time without injury to the race. Have we in stock more than we dare to detonate in a day, 1 day's time?

General STARBIRD. We have not more than we would dare to detonate if the fear is terrific injury to those outside of the combatant areas. There would be serious injury but I am talking about terrific injury of the nature of the Neville Shute type of explanation. However, I think what I was going to say, sir, has a definite bearing on the question you are asking me. If we could figure on being able to deliver every bomb we have and if we could figure that we did not need weapons for defensive purposes on our various fronts and for our

homeland, I think I could say in my own opinion we would have enough.

But with our philosophy we can expect to lose a great number of our bombs without ever being able to deliver them. We can also expect that by building defense for our homeland, such as our antiaircraft defense, equipping our antisubmarine force with nuclear weapons and equipping our tactical force with nuclear weapons, to serve as added deterrent to prevent the Russians from moving, therefore, sir, I have tried to answer your question two ways.

One, if we delivered everything and the second, if we delivered what we could expect to deliver.

(Discussion off the record.)

Mr. CANNON. The gentleman from Minnesota.

FRANCE'S BOMB TESTS

Mr. ANDERSEN. I noticed in the press the other day something to the effect that France was getting ready to explode its first bomb. They then are not party to this more or less unilateral agreement?

General STARBIRD. They have made no announcement that they will withhold. They have made announcements that they were proceeding with their program.

QUALITY OF WEAPONS STOCKPILE

Mr. ANDERSEN. What percentage of deterioration occurs through ordinary deterioration in our stockpile of bombs?

General STARBIRD. The uranium and the plutonium to all intents and purposes, does not decay.

Mr. CANNON. Mr. Pillion?

Mr. PILLION. General Starbird—off the record.

(Discussion off the record.)

Mr. CANNON. Your stockpile program referred to on page 35, what is the program referred to there?

General STARBIRD. The program is this, Mr. Chairman.

Now, the weapons we build must be completely dependable because they are going to be used by men who take them there and we often will not get a second chance. So we require in our designs a dependability of 99.5 percent. Now, to insure this, we must pull a sample of each type of weapon periodically from the stockpile, break that sample down, take the various switches, tubes, and the like, and see that they have lost nothing through any deterioration.

Then we must rebuild those and send them back. In certain cases, we fire the high explosive. The program concerned, sir, is one which will amount to some $14.660 million during the year. This is exclusive of approximately $10 million in components that are actually destroyed during the surveillance testing and then in addition to that, there is the cost of transportation to bring these samples back to a place where it is safe to work on them when we break them down this way and reassemble them.

Mr. CANNON. You are not at the present time doing any testing at all?

General STARBIRD. We are not doing any nuclear testing.

Mr. CANNON. Do you see any immediate time in the future when definitely, you will resume testing?

General STARBIRD. We do not know what the future holds with regard to testing. What we did in this budget was to make the assumption that we would not budget during this period of time.

Mr. CANNON. In the meantime you are retaining Eniwetok which is solely for testing. You are retaining it at some cost, when you do not expect to use it.

General STARBIRD. We are maintaining it, sir.

Mr. CANNON. I believe you have an estimate here of $9 million for maintenance.

General STARBIRD. That is correct.

Mr. CANNON. Now, how is it to be spent in maintenance?

General STARBIRD. We have there a capital investment in the way of facilities, powerplants, air-conditioning units, and the like which approximates $35 million. That would deteriorate rapidly unless we took some care. In addition to that we have movable properties of the order of $15 million. In the past at Eniwetok we have been able to get down at periods between tests to the order of 600 contractor employees there maintaining and carrying on the maintenance operation. The gross cost of that per month was of the order of $1 million a month.

We are going below that now and shipping out the equipment that we can usefully ship out and pickle the facilities that can logically be pickled.

We have a target figure, for example, of 550 men instead of the 600 plus, to be reached by July 1, dropping to something less than 400 by the beginning of January. However, even then because of the distance concerned and the work of pickling and shipping out, we estimate that the cost will be of the order of $9 million.

To get to this amount required a special survey in going over item by item what we were doing out there. Too, to answer your question, the $9 million that could put us on a minimum maintenance basis and to get out of there what we can usefully get out.

Mr. CANNON. Mr. Chairman, do you seriously expect to resume testing within the next fiscal year?

Is there a likelihood or probability?

Mr. MCCONE. There is no policy established as to what we might do in the event of the collapse of these discussions. I know that if they would break down we would resume underground testing. Whether we would resume a limited testing in the atmosphere——

Mr. CANNON. That would be in this country?

Mr. MCCONE. In this country, yes. Whether we would resume limited testing in the atmosphere remains to be determined. That has not been determined as a matter of policy.

Mr. CANNON. If necessary to resume our own air testing program, could that be done in some of the desert areas in the West? Is it absolutely essential that we have Eniwetok?

Mr. McCone. For any large test it would be essential, yes.

Mr. Cannon. You would not risk any large test in the western desert?

Mr. McCone. No.

Mr. Cannon. What is the nature of this surveillance? Is that merely monitoring any possible foreign detonation?

General Starbird. No, sir. What that means is inspection of our own stockpile to see that that stockpile is good.

Mr. Cannon. I see here you want $25.795 million. Because everything is at a standstill at this time, you could do that with $25 million?

General Starbird. Yes, we would do it with $25 million. However, this number was carefully screened before it came in. We did our best to get the overall estimate down. We are talking about quality assurance.

MAINTENANCE OF TEST SITES

Mr. Cannon. Did you realize at the time this was made, that there would be a period in here in which there was a practical certainty that there would be no resumption of testing?

General Starbird. This budget is drawn throughout on the basis that there will be no testing during this period. This figure reflects that as well as the other.

Mr. Cannon. You have never thought of abandoning Eniwetok?

General Starbird. We think it would be most unwise to abandon it until the situation in the future clarifies.

Also, sir, considering the capital investment that there is there and the facilities that are there, we believe that before it is abandoned, even if we were not to go back, the United States should make dead sure that it does not want to use it for something else.

We are canvassing other agencies and have found one user who will make limited use of those facilities that are there. I went down to Eniwetok the last time when it had been abandoned for 2 years and tried to put it back. At the end of 2 years without care, there was nothing worthwhile there. We had to start from scratch.

Mr. Cannon. It is in a tropical area?

General Starbird. Yes, sir. It is just off the equator. There is a constant wet wind that blows across there. The variation in temperature is not great but the wet, salt air comes in on everything.

Mr. Cannon. What are you doing at the Nevada testing site in the way of large-scale operations?

General Starbird. Sir, in the Nevada test site we are doing nothing in the way of nuclear testing of weapons. At the present moment though, two different power test activities are underway there.

Again, to give you a breakout of what our money is for there, we have $7½ million that is necessary to run the base facilities and to take care of the maintenance status of the location. We are doing something else and the budget covers that, sir, and it is mentioned.

We are putting back into shape certain tunnels and we contemplate building certain other tunnels. The overall costs involved run of the order of $11 million. In explanation of that, part of the work is necassary to get back in and see the results of the underground explosion we have fired to date.

Second, to go into a new area and start testing, if no preparations are made in the tunnels, would probably require nearly a year. If we are to go back to underground testing, we wish a site that is relatively well prepared. We are not contemplating the building of extensive side tunnels, putting in cables and all this material, but we are contemplating building enough, rebuilding and building additional certain tunnel tubes, if you want to call them that, so that if we do go back to underground testing we can get back relatively rapidly, sir.

Mr. CANNON. How much of the money provided for in the Nevada site is for air testing?

General STARBIRD. None is for air testing, sir

ESTIMATE AND ACTUAL COST

Mr. CANNON. I wish you would give us a tabulation here showing budget estimates in one column and in another column the actual cost and then in another column the differences in this program for the last 5 years including 1959.

General STARBIRD. We will do that, sir.

(The information referred to follows:)

Weapons program—Comparison of congressional submission with actual or estimated cost experience

[In millions of dollars]

	Congressional submission	Actual cost	Difference
Fiscal year 1955	$320.9	$238.2	−$82.7
Fiscal year 1956	271.1	257.4	−13.7
Fiscal year 1957	299.4	323.3	+23.9
Fiscal year 1958	452.3	433.0	−19.3

	Congressional submission	Present estimated cost	Difference
Fiscal year 1959 [1]	$544.6	$480.0	−$64.6

	President's budget	Revised budget [2] (H. Doc. 179)	Difference
Fiscal year 1960	$517.0	$495.0	−$22.0

[1] Excludes plowshare.
[2] The $22,000,000 reduction from the President's budget is due to changes in requirements and reductions based on actual fiscal year 1959 cost experience through Apr. 30, 1959.

Mr. CANNON. Are there any questions?

The gentleman from Tennessee.

EMPHASIS ON DEFENSIVE WEAPONS

Mr. EVINS. You are asking, General Starbird, for $15 million increase over last year and the total amount is $495 million. That lacks $5 million of being half a billion dollars. I, for one, do not think anyone can quarrel even with that amount if we had assurance that this would adequately forward our security. I am prompted to

make this observation because of the statement you made "because of our philosophy."

You said, as I recall it, "* * * because of our philosophy we will lose a certain number of these bombs. We will lose a certain amount of our security because of our philosophy."

Would it not be better to spend more money on protection so that we will not lose this great defensive equipment that we have? If we have a philsophy that we are going to lose a lot of this, perhaps we should put some more emphasis in another direction.

Will you comment on that?

General STARBIRD. Yes, sir; I can comment on that.

In the first place, most of the emphasis in this budget is on the defensive things we are talking about. They are the antiaircraft missile warheads. They are warheads in our lighter bombs to be located around the periphery so as to keep him from moving. There are warheads for antisubmarine use to keep him from moving.

Generally, these are the weapons, as I explained the other day, through recent development we are now able to build that we could not a few years ago. Now by the philosophy that I mentioned, and maybe the Department of Defense would be the one that could give you the best answer, but to me our whole national philosophy is that we are not going to engage in a preventive war. This being true, we have to be prepared if he does try a sneak attack. We have on example of what could happen in Pearl Harbor. We are trying to stay prepared against that now. I do not know whether you have an answer to your question.

Mr. EVINS. I thank you for your comment.

POSSIBILITY OF A PREVENTIVE WAR

Mr. CANNON. In that connection, may I ask, General Starbird, have you absolutely abandoned all possibility of a preventive war?

General STARBIRD. This is one you should ask the Department of Defense, sir. I am talking from what I feel is the basic opinion of the people of this country.

Mr. CANNON. You have been given to understand, you and your activity, your agency has been given to understand that there will be no preventive war under any circumstances?

General STARBIRD. I do not think that officially we have ever been told this. Let me again try to explain why. War plans are something that are kept most restricted in their numbers that have access to them. I do not go over and ask, "What is your war plan?" We press to make sure that the top level has considered requirements when they come to us, but I cannot positively say that I either know there is no such thing or there is any such thing.

SECURITY OF INFORMATION

Mr. CANNON. Who was consulted and how many were aware of the project when you dropped the bomb on Hiroshima?

General STARBIRD. Again I cannot give an indication of numbers. It was extremely few; that is all I can say, sir.

Mr. CANNON. Where were those few located?

General STARBIRD. The few were located in Washington, in SAC, which was not really SAC, the Air Force headquarters, in the local Air Force headquarters.

I can go so far as to tell you this: The commander of the base at Tinian told me 2 weeks ago that a man came out there with secret orders to build a certain site, to prepare a certain site, and that he had first priority to get an area available, and that man who was in command of the island of Tinian did not know the purpose.

Mr. CANNON. The man to whom the command came, not the man brought it?

General STARBIRD. The man to whom the command came. Of course, all the senior people knew this, but I am talking about the people in the field who must help on these things, generally, were not told of the purpose.

Mr. CANNON. In the aftermath, so far as you are able to determine, there was no leakage?

General STARBIRD. I do not know of any leakage, sir, that went to the Japanese.

Mr. CANNON. Mr. Fenton?

Mr. FENTON. I was one on the Military Committee at that particular time. There were certainly no leaks to that committee. I was on it. I was on the old Military Affairs Committee of the House before the unification of the armed services. That bombing of Hiroshima came as a surprise to the members of that committee. We knew nothing about the planning. So there were no leaks to the people on the committee.

Mr. CANNON. That is very interesting testimony, Doctor. You know that when we broke the Japanese naval code and had about 2 week in which we read every order out from Tokyo and all the tremendous advantages that it involved, somebody leaked, and the Chicago Tribune published it, and within 30 minutes after that newspaper hit the streets the code was changed.

The United States lost. There was a leak. And you also know there was a committee of five, Doctor, that for more than 2 years hid an aggregate in excess of $2 billion in the military appropriations bill and nobody ever knew it.

And we have a lot of smart people on the floor, too, but they did not know anything about it. They did not find it. But we don't want to take a chance like that.

Mr. Magnuson?

Mr. MAGNUSON. No questions.

DETERMINATION OF REQUIREMENTS

Mr. BOLAND. In the $1½ billion we are going to spend on the weapons program, in a sense you have no control over the amount of money you are going to spend. The military tells you what it wants or asking what you can develop. They say, this is what we want, we would like you to go ahead and develop it. You have to determine what the costs are going to be, but the requirements are all established by the Department of Defense, you just do the work they ask you to do or try to develop the things they want in the way of small weapons,

different configurations, different types and size, so there is little enough you can do with respect to these items here.

General STARBIRD. The requirements are given to us both for development and for manufacture.

Mr. BOLAND. You do not establish the policy; that is established beyond you and outside the Commission by the military itself and the Executive, I suppose.

General STARBIRD. That is right, sir.

Mr. CANNON. Mr. Magnuson?

Mr. MAGNUSON. All these weapons which you make which, I presume, include bombs and nuclear warheads for various weapons are consigned to the Department of Defense, are they not?

General STARBIRD. They are for the Department of Defense, though not all of them by any manner of means are in the hands of the Department of Defense. Some are still in storage in our hands.

Mr. MAGNUSON. Are you reimbursed by the Department of Defense?

General STARBIRD. No, sir; we are not reimbursed. The act provides that the Commission is responsible for the research and development and test of atomic weapons.

Mr. MAGNUSON. How about production?

General STARBIRD. Excuse me—and production of atomic weapons. We have defined, and again based on a definition in the act, what constitutes a weapon and the act says the weapon is not the means of carrying. So, with regard to a bomb, we build, develop, produce the bomb complete. With regard to the missile, we only do it for the warhead. But we have consistently come to this committee for the appropriations to carry out this function.

Now, there are some things outside of this responsibility as set out generally by the act, which we do for the Department of Defense but for which we receive reimbursement.

Mr. MAGNUSON. Since you are not reimbursed by the Department of Defense for these nuclear warheads and so forth, here is actually considerable additional and largely hidden costs of the Department of Defense missile program.

General STARBIRD. A large part of the AEC's program is a part of the overall defense effort, sir. It is brought in balance by coordination between the two and by supervision of the Executive Office.

Mr. MAGNUSON. That is all, Mr. Chairman.

Mr. CANNON. Dr. Fenton?

Mr. FENTON. I have no questions.

Mr. CANNON. Mr. Pillion?

Mr. PILLION. Mr. Chairman, I am very much impressed with the number of figures that appear in this report. I think they are a key to the efficient operation of the Commission and the staff.

I might commend the Commission and its staff for the reduction in unit cost. I know the overall costs are not reduced; we are getting more production. I think we should commend the Commission for their efficient operation.

I want to do that for the record.

General LUEDECKE. Thank you.

Mr. CANNON. We will resume at 2 o'clock tomorrow afternoon.

THURSDAY, JUNE 25, 1959.

NAVAL REACTOR DEVELOPMENT PROGRAM

WITNESS

VICE ADM. HYMAN G. RICKOVER, ASSISTANT DIRECTOR FOR NAVAL REACTORS DIVISION OF REACTOR DEVELOPMENT, DEPARTMENT OF THE NAVY

Mr. CANNON. The committee will be in session. We shall resume consideration of the budget estimates for the reactor program.

We have with us this afternoon Admiral Rickover of the U.S. Navy, in my considered opinion the most valuable, the most effective man who has ever been honored with the exalted title since John Paul Jones. He has accomplished the impossible, at least he has achieved what the authorities and experts said was utterly visionary.

So we are particularly fortunate in having the counsel and advice of a man of his ability and capacity and experience. And in view of his achievements we would like to inquire of him as to his recommendation on our fiscal program in this important feature of national defense.

Admiral Rickover, in the testimony this afternoon I hope that you will discuss the ways in which your unique organizational arrangement enables you to carry out your complex program without duplication, coordinating committees or other excess personnel or funds. I trust you receive the support you need from this committee and from the Navy and the AEC.

We realize how any man in your position is under pressure constantly to establish duplicate functions in the Department of Defense, to coordinate your work and provide your liaison with the Pentagon and with Congress, and may I encourage you to continue your resistance to all such unjustified pressures from us or anybody else. The direct working relationships you have established between yourself and us and the AEC and the Navy should be strengthened and supported as the most effective way to accomplish your important work.

If you care to make any preliminary statement before we take up the details of the program, we shall be glad to hear you.

Admiral RICKOVER. Mr. McCone, our Chairman, is here. Perhaps he would like to talk first.

Mr. CANNON. Mr. McCone is always in attendance. He is a very valuable man. We greatly appreciate the cooperation he is giving us at this time. He and this committee are working in cooperative liaison—one of the most satisfactory I recall since we have been holding hearings on the AEC budget.

So, at this time, I would like to ask, Admiral Rickover, about your program, the practical features of your work. I would particularly like to ask how the natural circulation reactor program is going at this time. We would like to know how we can further cooperate with you. And shall appreciate any advice and recommendations you consider pertinent to this hearing.

Admiral RICKOVER. Thank you, sir. First I would like to say that Mr. McCone has given me every possible support in the furtherance of the naval program. I am sure you know this, sir, but I would like

to say it right in this committee room. I could not get any more help than he has given me. He has been very considerate. He has taken time away from his own busy schedule to help me. I don't know whether this is the proper thing to say here, but I would like to pay him a great deal of tribute for his support.

Mr. CANNON. The country is fortunate in having two such able men collaborating with us on this important program.

Mr. MCCONE. Now you see what you did?

NATURAL CIRCULATION REACTOR PROGRAM

Mr. CANNON. Now, will you tell us how the natural circulation reactor program is going by this time?

Admiral RICKOVER. The joint congressional committee has recommended the authorization of the natural circulation reactor, and it is included in the atomic energy bill which is up for consideration by your committee. Separate studies on this type of reactor are being made by the Westinghouse Electric Corp. and by the General Electric Co. We will decide after a short period of time which has done the best job and decide which one will actually build the prototype.

The funds being requested are $18.5 million to build a land prototype of which we may obligate about $6 million in this fiscal year, and actually spend about $2 million.

The purpose of this new plant is to provide a quieter submarine than we now have. As you are aware, noise is a major problem in the operation of submarines. All machinery makes noise. We think we can eliminate the large reactor coolant pumps from our submarines' reactor plants, and we can also eliminate a considerable number of the big valves and piping. In this way we will have a simplified system. We must make our nuclear submarines as reliable as possible. This is particularly important when we operate them under the Polar ice. We must also make them as noise-free as possible, so that they cannot be detected by enemy submarines, and so that they likewise are in a better position to detect enemy submarines. Improved reliability and reduction in noise are the main reasons for this development.

Mr. CANNON. And you think you will get results?

Admiral RICKOVER. Yes, sir.

SHIPPINGPORT REACTOR

Mr. CANNON. I wish you would tell us, also, if you will, Admiral Rickover, about your plans for expanding the capacity of the PWR.

Admiral RICKOVER. That is the Shippingport reactor, sir, the first central station atomic powerplant the Commission has built.

Mr. CANNON. When did that plant go into operation?

Admiral RICKOVER. In December 1957.

Mr. CANNON. It has been operating safely ever since?

Admiral RICKOVER. Yes, sir; it has been operating safely. Since it first started operating it has been shut down a total of 116 days. Of these 116 days, 84 days involved the conventional turbine-generating equipment, and only 32 days were in any way connected with the nuclear part of the plant. Even these 32 days were not attributable to the nuclear reactor, but involved only the valves, pumps, and steam

generators in the reactor plant. So you see it is the ordinary equipment, and not the nuclear reactor which gives us most of the trouble. It has now generated about 340 million kilowatts of electrical power. It helps to supply the city of Pittsburgh with electrical power.

Mr. CANNON. That power is integrated with city power?

Admiral RICKOVER. Yes, sir. It is integrated into the Duquesne Light Co. system. The plant was designed for 60,000 kilowatts of net electrical power. We have been working for about 2 years on an improved nuclear core, and we find we can increase the capacity of that plant to about 150,000 kilowatts with the improved core and by making modifications to the nuclear portions of the plant. We are working with the Duquesne Light Co., a private utility, asking them to provide additional generating capacity at their expense. They did install additional generating capacity when the plant was first built. Instead of 60,000 kilowatts, they installed a 100,000-kilowatt generator. This was done by the company itself, at their expense. Now in order to make use of the increased capacity of the new core—150,000 kilowatts—additional generating capacity will have to be installed. This could be done in one of three ways: Either the utility pays for it or the Government pays for it, or else the Government takes over the plant.

The Commission is trying to work out an arrangement whereby Duquesne will pay for the added generating capacity, and we are currently negotiating with them. We are asking them to install 75,000 kilowatts more of electrical capacity instead of 50,000 which would take care of the output of the new core, because there may be future improvements in nuclear core design which might permit an even higher output. But the really significant thing is that we think we can get 150,000 kilowatts out of a plant that was originally designed for 60,000. This is a good indication of the strides that are being made in nuclear power. As you are also aware, I am sure, sir, all of the technology in this plant is completely unclassified. It is available to everyone in the United States, as well as to all foreign countries.

Most of what we are learning at the present time in the United States from an operating central station powerplant comes from the Shippingport station. So by going ahead with the 150,000-kilowatt modification we can, for a relatively small sum of money, contribute a great deal of technology which would otherwise require the construction of a new plant costing about $100 million to effect.

Mr. CANNON. What portion of the cost of this plant has been paid by the Federal Government?

Admiral RICKOVER. About 80 percent, sir. The part that was paid by the private utility was the electrical generating part, the turbogenerator. The utility also made a $5 million contribution to the nuclear portion of the plant. Roughly the construction cost to the Government was $50 million; that, plus the research and development cost, came to a total of about $95 million. So if you count the research and development plus the construction, about $95 million was paid by the Government and about $24 million was paid by the private utility.

Mr. CANNON. All results of your work, your formulas, and your data, all the know-how you have developed, is available to the public.

Admiral RICKOVER. Yes, sir.

Mr. CANNON. No private company has any patent upon any of them?

Admiral RICKOVER. No, sir; there is no private patent for any part of this plant. The Atomic Energy Act of 1954 provides that all patents belong to the Government in this field. I believe the law is just being extended to cover an additional 5 years on patents. The 1954 act provided that for 5 years thereafter the Government controlled all the patents in atomic power. This year there is an extension of the patent provision of the law which will extend it another 5 years.

NUCLEAR SUBMARINES

Mr. CANNON. Did the Shippingport generator antedate the powering of the *Nautilus* or did the *Nautilus* come first?

Admiral RICKOVER. The *Nautilus* came first. Many of the lessons learned from the *Nautilus* plant went into the Shippingport plant. This is a good indication of the fact that we can no longer make a distinction between military developments and commercial developments. We are learning a great deal from the Shippingport reactor which we use in our military plants and a great deal of what we use in the Shippingport reactor was learned from the military plants. There is a complete interchange.

Mr. CANNON. Common problems and common solutions.

Admiral RICKOVER. Yes, sir.

Mr. CANNON. When you make progress in one, you make progress in the other.

Admiral RICKOVER. Yes, sir.

Mr. CANNON. How many nuclear submarines have been commissioned?

Admiral RICKOVER. Six have been commissioned. Five are presently in commission. One, the *Sea Wolf*, was decommissioned. So we have five.

Mr. CANNON. How many are under construction?

Admiral RICKOVER. There are 28 under construction. There is a total, not counting this year's program, a total of 33 nuclear submarines either authorized, under construction, or commissioned. Of these 33, 9 are *Polaris*-type, 1 is the *Triton*, the radar-picket submarine, 1 is the *Halibut*, a Regulus missile launcher, and 22 are attack submarines.

Mr. CANNON. At what intervals will the submarines now under construction be ready for commissioning?

Admiral RICKOVER. About every 3 months, sir.

Mr. CANNON. How are the nuclear submarines which have been commissioned, which have joined the fleet up to this time, performing?

Admiral RICKOVER. They are performing very well, sir. A good indication of how well they are performing is the recent cruise of the *Sargo*. She left Mare Island, Calif., early this year and was at sea about 3 months. She steamed 19,000 miles and was on the surface for only 120 miles out of the 19,000. The average conventional submarine operates only about 18,000 miles in a whole year, and 75 percent of that time is spent on the surface, and the average speed is about 10 knots. The *Sargo* operated 99.5 percent of her time submerged, and

at a much higher average speed. All of our nuclear submarines are operating pretty much that way. They generally go on cruises of 10,000 to 15,000 miles, and they stay submerged 30 to 45 days at a time. As you know, the *Sea Wolf* was continuously and completely submerged for 60 days. Early this year the *Skate* made a 10,000-mile cruise. She was under the polar ice for 3,000 miles and surfaced at the North Pole. This gives you some indication of how well they are doing.

A great deal of this performance is attributable to the excellence of the officers and men, their selection and training.

SELECTION AND TRAINING OF CREWS

Mr. CANNON. You have been able to train and to maintain crews who have served effectively in this new capacity?

Admiral RICKOVER. Yes, sir. We have, up to the present time, though with considerable difficulty, because some officers in the Navy would like to assign crews to the nuclear ships by the IBM system—where you just crank in what you need and out comes the product. But, unfortunately where radiation is involved, we must be extremely careful. Radiation does not behave in accordance with the way the IBM machines tell it to, or the Navy regulations. So we must use careful selection and be sure we get people with the required mental capacity and aptitude to do the job.

The demands of nuclear power require higher abilities than are required for routine work. Nuclear power conveys a lesson and a warning. The Navy must learn that the new machines and weapons that are being developed will require higher abilities, higher professional standards. If we do not learn this lesson now, it will be too late. We must stop fighting the inevitable.

This matter has recently been the subject of correspondence between the Atomic Energy Commission and the Navy. Mr. McCone has commended the Navy for its way of operating the ships and the present system of selecting and training of the officers and crews.

Mr. CANNON. Please supply a copy of this correspondence for the record.

(The material referred to follows:)

LETTER FROM THE CHAIRMAN, U.S. ATOMIC ENERGY COMMISSION TO THE CHIEF OF NAVAL OPERATIONS CONCERNING THE OPERATION OF NUCLEAR POWERED NAVAL SHIPS

JUNE 23, 1959.

Adm. ARLEIGH A. BURKE, USN
Chief of Naval Operations, Department of the Navy.

DEAR ADMIRAL BURKE: This is in reference to your letters and instructions on nuclear-powered naval ships as follows:

Letter of January 21, 1958, transmitting BUPERS instruction 1540.38 "Personnel and Training Aspects of the Nuclear Propulsion Program," dated December 31, 1957.

Letter of February 20, 1958, transmitting OPNAV instruction 03000.5 "Operation of Nuclear-Powered Ships," dated February 6, 1958.

Letter of February 25, 1958, transmitting BUSHIPS instruction 9890.4 "Repair and Maintenance of Nuclear Propulsion Plants for Naval Ships, dated February 25, 1958.

Letter of November 25, 1958, transmitting OPNAV instruction 03000.5A (supersedes OPNAV instruction 03000.5A), dated November 25, 1958.

Letter of December 20, 1958, transmitting OPNAV instruction 03040.3 "Nuclear Reactor Incident; Procedures for," dated December 16, 1958.

The Commission has reviewed these procedures and instructions and has had them reviewed by the statutory Advisory Committee on Reactor Safeguards.

In section 161 b. and i. of the Atomic Energy Act of 1954 the Commission is authorized to:

"b. establish by rule, regulation, or order, such standards and instructions to govern the possession and use of special nuclear material, source material, and byproduct material as the Commission may deem necessary or desirable to promote the common defense and security or to protect health or to minimize danger to life or property."

"i. prescribe such regulations or orders as it may deem necessary * * * (3) to govern any activity authorized pursuant to this Act, including standards and restrictions governing the design, location, and operation of facilities used in the conduct of such activity, in order to protect health and to minimize danger to life or property."

In view of the excellence and completeness of the Navy's instructions from the standpoint of public safety, the Commission does not now deem it necessary or desirable to issue any Commission rules, regulations, or orders concerning nuclear-powered naval ships. The Commission does not, by reason of this determination, accept responsibility for operational decisions made by the Chief of Naval Operations.

We note that your instructions are designed to centralize in your office control over the movement of nuclear-powered naval ships, because of the potential hazard to life and property in the event of a serious accident. We approve and commend such a system which seems to provide for flexibility of operations for ships at sea or in harbors but emphasizes safety, which is of concern to the AEC.

It is our understanding that such instructions are prepared in consultation with the Chief of our Naval Reactors Branch. We are pleased that his counsel is sought because we also rely heavily upon his advice in being assured that Navy procedures adequately provide for the safety of the public. Obviously the AEC itself cannot carry out its responsibilities for public health and safety in the field of military nuclear reactors except by arrangement with the military services.

With respect to the design of naval reactor plants, the present practice is working satisfactorily whereby the design of each new class of reactors is summarized in a reactor hazards summary report and presented by the Naval Reactors Branch and the reactor contractor for review by the Commission's safeguards staff and by the Advisory Committee on Reactor Safeguards (a statutory body). The Commission then transmits to you for guidance the verbatim comments of these reviewing bodies. The Commission also relies on the Chief, Naval Reactors Branch, to keep it informed concerning any design changes or operating data which may have reactor safety significance, in accordance with the applicable memorandums of understanding between the DOD and the AEC and the Navy. Thus there seems to be an adequate system in being with respect to the safety of the design, repair, and maintenance aspects of these plants. The continued adequacy of this system, however, as the Commission and the Advisory Committee on Reactor Safeguards have stated in connection with several particular safeguards reviews, requires that the care and competence with which this procedure is presently being carried out be maintained.

Similarly, the great care and attention being given to the selection and training of personnel for the Navy's nuclear program has also been specifically cited by the the Safeguards Committee as essential to continued safe operation. In view of the possible serious consequences of a reactor casualty, it is of utmost importance that the operation of nuclear powered ships be entrusted only to persons whose mental abilities and qualities of judgment are commensurate with the responsibilities involved. Therefore, the Commission commends the policy and procedures in BUPERS 1540.38, which recognizes the importance of careful selection and detailed technical training of the officers and men who operate naval nuclear plants.

The Commission wishes to be of maximum assistance to the Navy in nuclear safeguards matters and to this end utilizes the Naval Reactors Branch as a means of liaison between the Navy and the Commission as agreed to in the memorandums of understanding. This arrangement has operated effectively: it permits the Naval Reactors Branch to draw upon all the technical knowledge available on this subject in the various parts of the Commission such as the Hazards Evaluation Branch, the Division of Biology and Medicine, and the Advisory Committee on Reactor Safeguards.

The AEC has under review the question of whether there should be any other method of adequately assuring and protecting the public health and safety with respect to military nuclear reactors. We will keep you informed of developments.

In summary, the Commission considers that the Navy's instructions represent a practical and effective means for providing maximum assurance of safe operation of nuclear-powered naval ships. As changes or additional instructions are issued in this area, the Commission would appreciate being kept informed.

Sincerely yours,

JOHN A. MCCONE, *Chairman.*

Mr. CANNON. But really to get satisfactory service and to insure the success of the nuclear-powered vessels, perhaps even to assure their safety, it is essential that you have the right to select men who are adapted to the particular service to which you assign them?

Admiral RICKOVER. Yes, sir. It certainly is where radioactivity is involved, because there is always the danger that something can happen to a nuclear reactor, no matter how careful we are in the design, and this could seriously affect the public. So in the operation of nuclear-powered ships, the Navy has the double responsibility, not only to do a good job designing and building the ship itself, but to take adequate account of public safety, too. For that reason we must be very careful in the selection and training of people, because otherwise serious consequences could result.

Mr. CANNON. As I recall, then, Germany had something less than 50 submarines at the beginning of the Second World War, and yet with that small number of vessels she swept the Atlantic so completely that she all but froze New England and New York that winter. No tanker could get out of the Gulf of Mexico up the coast. We had to build those two great conduits all the way from the Panhandle across up to New York to deliver oil which the tankers were not able to deliver due to the interference of the submarines. The only way we were able to combat the submarines was to take advantage of the fact that they had to come to the surface to recharge their batteries. Now you say that your submarines have remained under the surface as long as 60 days at a time.

Admiral RICKOVER. Yes, sir.

Mr. CANNON. If Germany had been equipped with such nuclear-powered submarines, we would have been helpless in that situation.

Admiral RICKOVER. I think if the Germans had had, and I will be conservative, 10 nuclear submarines, they could have won the war, probably by 1941.

Mr. CANNON. And in reducing the vibration and noise in operating your submarines, you are reducing the likelihood of detection by the enemy.

Admiral RICKOVER. That is correct. It also permits us to detect the enemy more easily because one of the problems is your self-noise. The less noise you make in your own ship, the easier it is for you to pick up the enemy, and the more difficult for the enemy to pick you up.

NUCLEAR DESTROYERS

Mr. CANNON. Now, Admiral Rickover, you have not only built a practical, successful, operating reactor when all previous attempts had failed; you have not only applied nuclear power to the submarine which men who should have known told us up to that time was im-

possible, but I note that you are also proposing to adapt nuclear power to destroyers. As I recall it, the last report we had was that the keel for the first nuclear-powered destroyer was laid down in May, within the last month?

Admiral RICKOVER. Yes, sir.

Mr. CANNON. I am a little surprised to note that the Navy has not included a nuclear destroyer in the fiscal year 1960 shipbuilding program. We have not estimates for a nuclear-powered destroyer building program. Could you tell us how the development of the nuclear-powered destroyer is coming along, and when you will be ready, technically, to build such a destroyer?

Admiral RICKOVER. We are building the first nuclear-powered destroyer now. We are ready to build more. The nuclear destroyer—or destroyer leader, as they are called—which was in the fiscal 1959 shipbuilding program will be finished before the conventional powered destroyer leaders which were authorized in the fiscal year 1958 program. That is not entirely due to the difference in building time. It is partly due to the fact that the Navy did not have money to start the conventional ships any earlier. But we are building the nuclear destroyer just as fast or faster, in actual building time, as the Navy is building the conventional ones.

Mr. CANNON. Have you ample funds for that purpose?

Admiral RICKOVER. Of course, there are never ample funds. You know there is the question of the carrier and the other ships. Another nuclear destroyer leader would cost about $40 million more than a conventional one. But for that $40 million there are considerable advantages. For example, part of the $40 million pays for the nuclear fuel for the ship, which means that the construction cost includes the fuel for the first 3 to 4 years. The nuclear destroyer would be able to steam for 100,000 to 150,000 miles continuously at full power.

It also means that we won't have to refuel that ship for a long time. So that if a war were to break out today, if our oil supplies were to be cut off, we would not be dependent on very scarce oil. Of course, you know the effect, you mentioned about tankers not being able to get through. Now at that time it was possible to build the pipe lines and get more oil from the United States itself, but it is a question whether 10 to 15 years from now, even with pipelines there will be enough oil in the United States to carry on an extensive war. So there is a big dividend from having nuclear-powered ships. You can actually store up labor and material during peacetime which does not spoil prior to the war.

In the last war the thing that limited our output was our availability of labor. With nuclear power, you have the opportunity to use that labor in peacetime and to store it. You can put all of the nuclear cores you would use in the entire Navy for a whole war into a couple of warehouses. You would not have to build tankers to carry oil. You would not have to build oil tank farms. You would not have to make the steel to build these things. You would have the nuclear fuel already available.

In my opinion it is unwise to build too many obsolescent ships. I believe we should build more nuclear powered destroyers because a nuclear-powered ships immediately obsoletes all the others of its type.

There are three conventional destroyer leaders proposed by the Navy in the fiscal year 1960 shipbuilding program; these ships are scheduled for delivery in 1963. Even if one of these were made nuclear it would not get to sea until about 2 years after the first nuclear destroyer leader now under construction. If none is included in this year's or next year's program, that will mean at least a 3- to 4-year gap between the first nuclear destroyer going to sea and delivery of the second one. From a technical standpoint, as far as the nuclear propulsion plant is concerned, there is no reason why any or all of the destroyer leaders in the 1960 and later shipbuilding programs could not be nuclear powered. It is a question of dollars. As I said earlier, it would cost about $40 million extra per ship including the cost of reactor fuel to make any of these destroyer leaders nuclear powered. But I must reaffirm that it may be a grave error to build second-best weapons of war. In war you either win or lose; there is no such thing as coming out second.

Mr. CANNON. You would not recommend the building of a conventional-powered destroyer then?

Admiral RICKOVER. Now you are putting me on the spot, Mr. Cannon.

Mr. CANNON. I withdraw the question.

Admiral RICKOVER. I will answer your question. Admiral Burke has problems of getting a certain number of ships. In my opinion he would make out better by getting a smaller number of nuclear ships than a larger number of conventional ships. That is my opinion. But I am not in his position and I do not have his responsibility. I would take a smaller number of nuclear destroyers rather than a larger number of conventional destroyers.

Mr. CANNON. You would not advise the building of a nuclear-powered carrier?

Admiral RICKOVER. The thing I addressed myself to in previous testimony as far as the carrier is concerned was whether it should be conventional or nuclear powered.

Mr. CANNON. I am not going to ask you if you advise the building of a nuclear carrier, because this committee has determined not to build one.

VALUE OF NUCLEAR REACTOR PROGRAM

I am particularly pleased, and I think I express the views of the committee, that the Atomic Energy Commission is giving you such complete support in the naval reactor program. It is gratifying to all of us because we realize that the future is inextricably wrapped up in the development of atomic energy and in the adjustment of atomic energy to both modern warfare and modern industry. The nation which does not make progress in this respect will be left hopelessly behind. Atomic energy means the future production of electric power at minimum costs, and electric power is indispensible in modern civilization.

It will make possible the development of power at such an incredibly low cost that the entire human race, if they will just quit thinking about war, about preying upon each other, murdering each other and robbing each other; if they adopt the ways of peace, there will be no one who cannot enjoy not only the necessities but all the

luxuries. We are dealing here with one of the most vital problems that confronts the country today.

It is gratifying that the Atomic Energy Commission, which has made such meager progress up to this time—in comparison with it opportunities—is cooperating with you.

In looking over the progress we have made up to this time, Admiral Rickover, it is more clearly evident that a major proportion of all the nuclear reactor technology developed in this country is the product of your program, both the reactors in time of peace and nuclear powered war vessels in time of war.

For many years we have had a parade of witnesses before us, including some of the ablest men of the Nation, testifying to grandiose plans for development of nuclear power, none of which were realized. You are the exception to the rule. The plans you have developed, you have put into successful operation. You have added to the prestige of the United States throughout the world. You have contributed immeasurably to the safety of the Nation. As a matter of fact, without the agencies you have developed and put into successful operation our national defense would today be hardly dependable.

IMPORTANCE OF NUCLEAR ELECTRIC POWER PROGRAM

We are all particularly interested in this Shippingport nuclear power station. You have not only shown how successfully it can be developed, but you have disposed of many seemingly insurmountable obstacles. There was widespread alarm throughout the Nation, and many organizations, social, political, industrial, even the labor unions, were doubtful about permitting the construction of this reactor in such a heavily populated area. Everywhere anxiety was voiced lest it get away from control and create devastating destruction of life and property. You have shown that it not only can be built to achieve the purpose for which it was devised, but that it can be done safely without risk to local populations or property interests.

We would like to see the Shippingport station exploited to its fullest capacity. We are glad, Admiral Rickover, that the public utilities and the Government are cooperating and that private utility and the Government are cooperating. Sometimes those who are unkindly disposed toward public power like to leave the impression that the Congress and the committee wish to establish a public monopoly, a Government monopoly of power. Nothing could be further from the truth. I have never heard anyone seriously suggest in Congress or in the committee that we should develop a monopoly of public power. But we do want to guard against a monopoly by private power. Whenever we permit any combination of power corporations to attain a monopoly of electric or atomic power in this country the consumer will be exploited. That is too much power to give to any man or any group of men.

All we desire is that we have, as we have at Shippingport and as we have at TVA, yardsticks whereby we can demonstrate, whereby the public can see, how cheaply power can be developed and distributed. We want private enterprise and private utilities to handle the bulk of the production and distribution of power throughout this country and at a reasonable profit. But we also want the policeman on the corner, this yardstick, which will insure the distribution of this neces-

sity of life and industry at a reasonable price to the consumer and at a reasonable profit to the utility. We do not want to place the consumer in a position where he would have no recourse, either as to rates or terms of service.

At Shippingport and at TVA and at all public power installations, if there is a lack of service, or the arbitrary imposition of exorbitant rates, they can come to the Congressmen that they elected, can come to the Congressmen under their control, and secure a hearing. But once the industry is in the hands of a national private monopoly, the public is defenseless, the consumer is helpless. So that up there at Shippingport where private industry is cooperating with the Government under your wise supervision, we are establishing the ideal situation in which no one monopoly, either public or private, can dictate to every family in the United States the amount that it shall pay on its monthly electric power bill or dictate to any industry the cost of that important factor in its economy. Where there is both Government and private enterprise there will always be some authority to which the consumer can go to secure a review of any complaint that they may have against those in control.

RELATIONSHIPS WITH CONTRACTORS

I would like to ask you, Admiral Rickover, what has been the relation, both in the adaptation of nuclear power to naval vessels and in the construction of the reactor, what has been your relation with the contractors?

Admiral RICKOVER. It has been made clear to me, since inception of my program, that it is essential to have a headquarters organization in Government that understands as much as does the contractor about what is going on. Otherwise the headquarters organization is nothing but a contracting outfit which merely decides what jobs are to be done, who the contractor is to be, and leaves it entirely up to the contractor.

A qualified headquarters organization is particularly necessary when nuclear reactors are being built for installation in naval vessels, where the reactor has to fit into a given space, and where the weight is limited and set early in the design of the ship. It is the same as the relation between a jet engine and the air frame. You cannot build them separately. We have to know what is going on in all parts of the design of the nuclear plant and ship, and we have to work closely with the contractor, because we are responsible for the end product. Neither side can get off on its own. Both have to work closely together and they have to develop confidence in each other.

Mr. CANNON. Too often the Government organization becomes the victim of the industrial organization with which it is contracting, and we wish to express hearty approval of the type of relationship you have set up with industry. It is clear where the real responsibility for these programs rests, and so far as we are concerned, we hope to see you continue this philosophy.

Mr. EVINS. Mr. Chairman, I want to say on the record that I heard with interest the statement of the Reactor Development Division by the new chief, Frank Pittman. I knew this young man years before he went in the Government service, and in an early day he was marked as a brilliant man sure to succeed. He has now become head of this

division. In our testimony before the committee previously we have had information that atomic power would benefit the public generally in 10 years, 15 years, maybe 20 years. I was a little disturbed by my friend when he used the phrase that the next generation will receive the benefits of atomic power. That challenged my thinking. Are we projecting progress in this area further and further and further into the future, or are we making the progress in this great, important and significant field that we should? We know that electic power is essential and important and the fossil fuels, coal, and oil are important. They are using atomic power in England, but not in our country. When we have a fight up here on the floor we have to fight the private power people. We have to fight the representatives from the coal areas and it is natural the representatives from those areas would rise in defense of that section. And all the generator manufacturers, they have had 95 percent of the business, and their prices have gone up 50 percent over the past several years. When you inject a little foreign competition, one bid for one generator, that saves $6 million, why, you have to combat those sources. So I appreciate the difficulties with which the members of this great agency are confronted.

I just merely want to express the hope that you will go forward with zeal, with dedication for achievement and accomplishment in the public interest and surmount these difficulties, these great pressures, these drawbacks, these things that would project the useful development of this great power to the public benefit into the next generation. Let us not make it 25 years. Let us make it in less time, frankly.

DESIRABILITY OF ELIMINATING SOME RESEARCH PROJECTS

Mr. Boland. While we have Admiral Rickover here, would he care to express an opinion on whether he believes that all the different types of reactors or reactor concepts that we are now engaged in, whether or not all of this is necessary? Do you believe we can eliminate some of the reactor program and save millions of dollars, or do you think that we ought to go ahead in pursuing to the end the program that we have now in being to determine which is the best reactor, and probably the most economical, the most feasible in the long run? Are there any reactor concepts now you think we can eliminate and save money?

Admiral Rickover. You are asking me a difficult question. You must realize that I am not as fully familiar with the entire reactor program as Dr. Pittman and Mr. McCone, but I will attempt to answer your question. If I were doing it, I would join some of them together. In my opinion there are too many different approaches being followed.

Mr. Boland. This is the feeling I have had since I have sat on this committee. I don't know what the total overall amount of money we are expending in reactor concepts is. Maybe General Luedecke can tell me. But this year we are spending a considerable amount of money on the thing and we have spent it in the past. That is what is bothering me. That is why we want to have some of the expert testimony that Admiral Rickover is giving. I understand you are not completely familiar with all of them, but you have a good gen-

eral knowledge of all reactors and this is the question I would like to have answered.

Admiral RICKOVER. You understand that the Commission itself is not always a free agent in this decision. Even your committee has some influence.

Mr. BOLAND. That is right, except we bend to the knowledge and wisdom and ability of those who are experts on that side of the table. Generally speaking, this committee goes along. We may have our differences once in a while with the legislative committee, but the problem of what we ought to pursue to the end to determine what is the best kind of reactor, I think this is an important question, because this is a field in which we have spent millions and will spend millions more.

Admiral RICKOVER. Your problem with the Atomic Energy Commission is no different than it is with the Department of Defense or any other Government agency. In my opinion too much money is spent on research and development. I personally feel we could get more and go further in all fields of Government research and development by cutting out some of the projects and concentrating people on a smaller number. It takes time to spend money. But spending money does not by itself guarantee progress. Furthermore, you soon get to the point where you have created vested interests in research and development. You soon have a large number of groups who keep on working in research and development because it has become their livelihood. The true measure in any research project is whether the people who are doing it really believe in it, actually believe in it, rather than just working at the job. From that standpoint it is my considered opinion, and I am not talking about the Atomic Energy Commission alone, but of all Government research, we are doing too much, we are spending too much. A man responsible for research and development must be coldblooded. He must have the stamina to kill projects. Anyone can be in charge of a job, where all he has to do is make more and more contracts, ask for more and more money, and never do the disagreeable chore of stopping some of the projects. And, when the money is limited, just spread it out over all of them. This requires no judgment, no ability, no knowledge.

Mr. BOLAND. I appreciate your answer. I don't expect the AEC to give me any answer to the questions I propounded because I hope to pursue this matter a little bit more fully with respect to particular reactors when we get into the reactor program. Thank you, Admiral.

NUCLEAR AIRCRAFT

Mr. CANNON. I would like to ask one more question, Admiral Rickover. You have been remarkably successful in building a reactor and in powering the submarine. What about the problem of propulsion of the airplane by atomic energy?

Admiral RICKOVER. As you know, sir, this is not my responsibility. I believe that Chairman McCone and the Joint Congressional Committee and the Secretary of Defense have that problem under consideration right now. I think Mr. McCone is the proper man for you to ask that question. In my opinion it is a very difficult problem, and probably the difficulties are not yet fully understood. I believe

it will take longer to accomplish it than even the optimists now say. It is very, very difficult. It is more difficult than anything I am undertaking.

Mr. CANNON. But you think it can eventually be solved?

Admiral RICKOVER. Yes, sir. There is no problem of that type that cannot eventually be solved. But you have to decide whether you are willing to pay the price to solve it, and whether it is worth the price. The issue is for the Defense Establishment to decide whether it really wants it. I am not sure whether the Defense Establishment has decided. That is the nub of the problem. In my opinion you should find out from the Secretary of Defense whether he really wants it.

Mr. CANNON. Well, presumably in solving the problem there are one or two fundamental things which stand in the way, one or two major obstacles. Of course, the very first one is shielding and then there are metallurgical problems. Now we are spending at the present time, as I recall it $150 million annually. Of course until we solve the basic problems the rest is useless. No matter how successfully we solve all the remaining problems, the machine will not fly. What would you say should be the basic problems on which we should first concentrate our time and attention and money?

Admiral RICKOVER. I would concentrate my time and attention on the reactor, not on any ancillary parts.

Mr. CANNON. On metallurgy or shielding.

Admiral RICKOVER. The reactor includes the metallurgy and also includes the shielding. But there are a lot of auxiliary developments that have gone along with it. Unless you lick the reactor problem, there is no point in trying to lick the others. The other problems are much easier to solve, once you have the reactor. Until you get a real workable reactor I would not go and work on airframes and a lot of other things. I would first get a reactor operating practically and safely, not merely one or two brief demonstrations.

Mr. CANNON. What would that mean in terms of money, Admiral Rickover?

Admiral RICKOVER. You realize, sir, you are asking me questions which are not in my direct field of supervision. There are other people here who are more qualified to answer.

Mr. CANNON. It is merely a collateral question, Admiral Rickover. So far as the committee can determine at this time, we are on a dead center.

Admiral RICKOVER. My opinion is that to develop the reactor you need a minimum of another billion dollars, just for the reactor, and possibly another 5 years time. These are round figures. I am just using my intuition. It is a very difficult problem. It is for this reason that I suggested to you, sir, that you ask the Secretary of Defense what his military requirements are, because obviously if you are doing this without a military requirement, then you don't know whether you are doing the right thing. The first thing that should be established is whether the Department of Defense wants it.

RUSSIAN PROGRESS

Mr. CANNON. What do we know, Admiral Rickover, about the progress being made by Russia in these various fields, in the nuclear propelled ship, and the proposed nuclear propelled airplane?

Admiral RICKOVER. I will take the nuclear airplane first, sir. I think they have done a good job at copying our propaganda. Now we are copying their propaganda. If you read their propaganda carefully, it is almost a verbatim copy of the stuff that some of our people have put out. I think it is an interchange between groups in both countries that are interested in doing that job and getting funds. This is my impression of the propaganda statements that are coming out.

The question I would ask myself about the Russians on the nuclear powered airplane is: Why would they want to have it so fast? Of course we frequently say they want it for a propaganda victory. My own opinion is that the Russians are too hardheaded to spend large amounts of scientific and engineering talent and industrial facilities just for a propaganda victory. For instance, sputnik was not propaganda. Only when you are trying to fool someone is it propaganda. Sputnik was actually in orbit where it could be seen. Therefore it was not propaganda. I know of no case where the Russians have devoted large amounts of technical manpower and energy for purely propaganda purposes. I would discount the propaganda angle. That is my opinion about the airplane part.

CAPACITY OF RUSSIA TO CONSTRUCT NUCLEAR SUBMARINES

I don't know whether my Chairman agrees with me or not. He represents the Commission. These are my personal views. So far as the nuclear powered submarines are concerned, they are highly important to the Russians. There have been many rumors over the past few years emanating from Russia, some of them discounting the fact that we even have nuclear powered submarines.

The stories you hear coming from individuals and contractors in the United States depend on what they are trying to sell. For example, if an industrial organization is interested in building more or different types of atomic submarines or parts of them, they come out and make statements that the Russians are doing this or that, and that it is essential to our national defense to embark immediately in what they recommend. This might even be true of the nuclear powered airplane. It is my opinion that the reason they concentrated on an atomic powered icebreaker first is because it was an easier job to do. They are having some trouble with it, because it has not been in operation as soon as they said it would. This is natural and to be expected with a new type plant. The icebreaker *Lenin* has three reactors. I assume that this ship will be used to try out these reactors, and if they can operate these reactors successfully on the *Lenin*, there is no reason why they cannot operate them successfully in a submarine. So I believe that in a relatively short time the Russians will have nucleared powered submarines. And since they have the capacity to build 100 submarines a year, they can outstrip us in a very few years. We are requesting funds for only three next year. The Russians have capacity for a hundred. Does that answer your question, sir?

Mr. CANNON. Yes, sir. There has always been a disposition, Admiral Rickover, to underestimate the Russians. It seems incredible that they could outstrip a great scientific nation like the United States.

So it might have been our good fortune when they jolted us with the sputnik, and demonstrated they could do what we had not been able to do up to that time. Is it possible that the same thing might be true of progress in other fields of atomic energy?

Admiral RICKOVER. Yes, sir. You know I did not say they were not capable of building atomic powered submarines. I think they are quite capable of doing so. We should take advantage of the lead we presently have and exploit it. We are not exploiting it enough. The great danger we face from Russian submarines is an attack on our country, particularly on our coastal cities, by Russian submarines that carry missiles. You saw in the paper recently where we took pictures of the superstructure of a Russian submarine off Iceland that had the ability to launch missiles.

NEED FOR ADDITIONAL NUCLEAR SUBMARINES

Mr. CANNON. In your opinion those illustrations presented a fairly accurate picture of what they might be doing?

Admiral RICKOVER. Yes. I certainly would assume that they have submarines that can launch missiles. We have submarines that can launch missiles. Why not the Russians? And I certainly would assume that their missiles have a range of at least 200 or 300 miles. If a submarine lies off our coast with 200 or 300 mile missile range; if it fires a missile with an atomic or hydrogen warhead; if it places that missile properly; one missile can effectively destroy a city. Since the best way we now know to counter the Russian submarine threat is by our own nuclear powered submarines, we should build more of them and with no further delay. Congressman Van Zandt introduced a bill in the House last year to build more nuclear powered attack submarines. The Navy was against it because, with the limited budget, it would affect the building of other types of ships. I certainly would build at least 10 more nuclear attack submarines every year just as soon as I possibly could.

Now, this, of course, is a budget question. I am not competent to say whether there should or should not be an increase in the budget. I know you are pretty well holding the line on the budget, so what I am saying may not be popular with you.

Mr. CANNON. It is not the amount we spend. It is how we spend it, where we spend it. We might spend twice what we are spending now, and if we did not spend it in the right way, we would get less than what we are getting now. Maybe we could spend half of what we are spending now and spend it more effectively.

Admiral RICKOVER. You should spend more on antisubmarine warfare, including nuclear powered attack submarines. Mr. Mahon asked me my opinion about the effectiveness of our antisubmarine warfare. I told his subcommittee that I had been in the Navy since the First World War. I was in submarines between the two wars. I remember the statements then being made that we were overcoming the submarine menace. Looking back, it is plain that we were almost dormant in that effort. We did not make much progress between the two wars, and we nearly lost the last war because of that.

My opinion is that relatively, we are no better off today than we were before 1941. That is, we are in no better position to defeat today's Russian submarine menace than we were to defeat the German submarine threat in 1941. If fortune favors us and we have the privilege of looking back from the vantage point of 10 to 15 years from now, we probably will find that relative to today's requirements we

are doing no better than we did between the two world wars—that we have not learned the lesson.

I believe that the main function of the Navy should be antisubmarine warfare—to defeat the Russian submarine menace.

Mr. CANNON. That being true, and I think most informed men that have testified before the committee seem to agree in that respect, as you say, if we are fortunate enough to be alive 15 years from now, in order to be in the position where we would be safe 15 years from now, what program would you follow immediately?

Admiral RICKOVER. There are many things that have to be done, sir. A program that could be followed immediately, and one we know would be worthwhile would be to build more nuclear attack submarines without delay.

Mr. CANNON. Mr. Jensen.

Mr. JENSEN. Thank you, Mr. Chairman.

COOPERATIVE EFFORT

Admiral Rickover, all America honors you for the service you have rendered this Nation. There was a time of course when your great ability was not properly recognized nor compensated. I have heard you make several talks. I have always felt, after listening to you, that you did not by any manner or means take all the credit for it yourself. You have had a lot of good help. I wonder if you would tell the committee of the cooperation that you have had with nuclear scientists, metallurgists, and Government and private enterprise? Would you just give us a short briefing on your heartfelt feelings relative to that? I don't want to detract from the great service you have rendered.

Admiral RICKOVER. I am glad you mentioned that, sir.

Mr. JENSEN. The reason I have asked that is that I have sat on this committee for 7 years, I have listened to these men from the Atomic Energy Commission, the Commissioners themselves, and the heads of the different departments of the Atomic Energy Commission, and I have always marveled, in fact I have many times thanked God for such devoted men. I know the American people are grateful not only to you, but to every one of the great scientists, these devoted patriots, who have made it possible to bring the atomic sciences in development up to its present status. Of course, in America we are never satisfied. That is what makes America great. Too often we are critical of the other fellow and perhaps it should be. We have free speech and free press and we want to keep that. We have built here the greatest nation on earth under the free enterprise system. I know that you and every other good American wants to preserve that free system of government. I have enjoyed today your answers to the questions which have been propounded to you and you are very outspoken in your beliefs. You are not afraid to speak out. You say what you honestly think, as God gives you the power to determine your actions.

Now I ask you this question: You have, as you have said many times, had the scientific knowledge of many other people, you have brought those thoughts together and from that you have been able to carry one. Would you care to comment on that?

Admiral RICKOVER. Yes, sir. I appreciate very much that you have raised this point. I can say in a very heartfelt way that I have been

more fortunate than anyone I know to have been in the position where so many fine people have helped me. For example, sitting at this table are Mr. McCone, our Chairman, General Luedecke, our General Manager, Mr. McCarthy, who handles finances, Dr. Pittman, our Director of Reactor Development. They do a vast amount of work which enables me to do my own work. Their names never get connected with some of these wonderful things. All they can get is the satisfaction of knowing that they have contribtued to it. The same thing applies to the Members of Congress who help. Without the help and understanding I get, the whole Commission gets, from Congress in appropriations, we could not do our job. This also applies to the large number of people in industry who help. They all contribute. And particularly the fine men and women in my headquarters organization who have dedicated themselves wholeheartedly to the task. To all of these people and to their understanding families I pay tribute.

Mr. CANNON. Mr. Jensen, you may continue.

Mr. JENSEN. Admiral Rickover, you may proceed.

Admiral RICKOVER. Mr. Cannon, while you were occupied I was answering Mr. Jensen's question about the help I had received from various sources. I would like to repeat it in the event you may not have heard.

I mentioned our chairman, Mr. McCone, our general manager, Mr. Luedecke, Dr. Pittman, and others here who have always worked hard to make it possible for me to do my work. Nobody ever hears about them except when things go wrong.

Also, that Members of Congress, through the years, have understood and have helped, and that many people in industry and in my own organization have helped. I say in all humility I have not done this job by myself, I simply have been fortunate to have been the head of this organization and have the opportunity to have all these fine people work with me and help me.

No one man can do a job like this all by himself. No one man can have all the ideas. About all he can do is make it possible for his people to do the job.

Now, I would like to amplify my remarks and touch on another aspect of the problem. That is: With the help of the Commission I have pursued a policy for the last 10 years of getting private industry to do everything. That is in the naval program we have not supplied $1 to any private companies for putting up facilities. You are familiar with the aviation industry where, I believe, about 98 percent of the facilities belong to the Government. I have developed competitive sources of supply for the naval program. Private industry has stepped in and has built these facilities with their own funds, so that we are now buying practically everything for the nuclear ship propulsion plants on lump-sum competitive bidding.

It is possible to do that. To that extent, private industry has contributed and can contribute. I just want to point out that it is possible for private industry to do this. They have cooperated very much in the design and development, too. After all, the detailed work on these plants, the design, the development, and the construction has been done by private companies.

Mr. JENSEN. Did you ever know of a private company that did not cooperate fully?

Admiral RICKOVER. Yes; there are private companies who have not cooperated fully.

Mr. JENSEN. There are?

Admiral RICKOVER. Yes, sir. Private companies are bad at times just as Government organizations are bad at times. I could not sit here and say that every private company is always good or that every Government agency is good.

Mr. JENSEN. I was really interested in your straightforward answer, Admiral, to the chairman's questions. He asked you a question which you were willing to answer. That question was, "Would you build atomic-powered carriers rather than conventional type if you had the say?"

Admiral RICKOVER. I would much prefer to build atomic-powered carriers to conventional ones.

NUCLEAR DESTROYERS

Mr. JENSEN. Then he asked you if you would build atomic-powered destroyers. I do not believe you had an opportunity to answer that.

Admiral RICKOVER. May I answer that now?

Mr. JENSEN. Yes.

Admiral RICKOVER. Yes, sir; I definitely would build more atomic-powered destroyers. We have gone far enough in the development of the nuclear-powered destroyer to know that it is going to be successful. We have more knowledge about the nuclear plant of the atomic-powered destroyer than we ever had about the one in *Nautilus* when we were building it. Here, again, it is my firm conviction that we will get more protection by putting the same amount of money in atomic-powered destroyers, even though we get a smaller number of them, than we would by building conventional ones.

Mr. JENSEN. Would you say that we could build atomic-powered destroyers, fewer, for the same amount of dollars that would be just as effective in war as conventional type, dollar for dollar?

Admiral RICKOVER. Yes, sir.

Mr. JENSEN. Would you say the plus would be on the side of the atomic-powered destroyer?

Admiral RICKOVER. Yes, sir, Mr. Jensen. You must bear in mind now, that I am not the officer responsible for operating the Navy. That is Admiral Burke, but you are asking my opinion.

Mr. JENSEN. Your judgment is appreciated.

Admiral RICKOVER. Today almost any new military weapon or weapon system costs tremendously more than previous ones. I believe that the increase in cost for atomic-powered ships on a percentage basis, is much less than is the case for improvements in other weapons.

DEVELOPMENT OF NUCLEAR CORES

For example, the nuclear powerplant in the *Skipjack*, the fastest submarine we have, costs $12 million. We are buying it on a competitive lump-sum basis. Furthermore, we are making developments in the nuclear cores where we are doubling their life without additional cost. Two weeks ago the *Nautilus* finished operating on her second core. That core gave her 93,000 miles as compared with 62,000 on the first core.

We are now building nuclear cores that will give us 50 percent more life than even this second core. We get this without any significant

increase in cost because the main cost in construction of a core is the fabrication cost. The only additional cost is the use of more uranium. We are making considerable progress that way.

NUCLEAR AIRCRAFT CARRIERS

For example, take the atomic-powered aircraft carrier. I do not know whether Mr. Cannon will always remain opposed to carriers—I hope he does not—but the atomic-powered carrier can carry nearly twice as much aviation fuel as a conventional carrier, because in the atomic carrier a lot of the volume which is used in the conventional carrier for carrying ordinary oil can be used for carrying aviation fuel.

So, in the case of the carrier, to exemplify this point, we get a ship which, at the firing point, has the effectiveness of nearly two carriers. In addition it is not dependent on a chain of tankers. It is fairly independent of a considerable portion of the normal logistics support, particularly in wartime.

NUCLEAR SUBMARINES

Mr. JENSEN. Does your same thinking apply to submarines?

Admiral RICKOVER. Yes, sir; you see, the conventional submarine can make 18 knots for about a half hour; then she is finished. That is all she can do with her storage battery. The nuclear submarine can steam at full power for months. Again, nuclear power not only reduces the need for direct logistics support, but also obviates the necessity of building advanced bases or having tenders in some forward area, because if you want the submarine to be far-ranging and if she runs out of fuel she has to find fuel at a forward area or else return to her base. The nuclear submarine does not have these limitations.

I am sorry I am now not permitted in this hearing to tell you of the many unusual things our nuclear powered submarines have done. They are highly classified. I do not believe you would want me to mention them here. You would be very gratified at what they have been able to do. They have done things which no other vessels of war have ever been able to do.

Mr. JENSEN. I think the committee has pretty good knowledge of that thing.

Admiral RICKOVER. Have I answered your question, sir?

Mr. JENSEN. Yes, indeed, you have; Admiral, thank you for it. Of course all, or a lot, of this information given by the Atomic Energy Commission relative to atomic energy of every nature and the things that go into it make it and all of its ramifications, of course, not completely understood by common, ordinary men such as I.

But we have received quite a liberal education over the years in listening to these people who have come before us from the Atomic Energy Commission. I can only say in closing that I never leave this room after listening to the Atomic Energy Commission and its staff but what I feel just a little safer, I feel America is just a little more secure than I did when I walked into the room. I certainly hope and pray that God will give them the power to carry on the knowledge to protect this great beloved Nation of ours. That is all I have to say.

Mr. CANNON. The gentleman from Tennessee.

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Mr. EVINS. I think we all appreciate the great contribution of our American industry. We are proud of the great industries in our country and what they have done. I think it might be well to point out for the record that we would not have the advance we have today if we had left it to industry alone; if we did not have the stimulation of the Atomic Commission, the Congress, and this committee.

The admiral mentioned that some of the industries would not cooperate. They will cooperate if Congress appropriates the money and subsidizes them 90 percent like they have at Shippingport and gives them tax amortization and writeoffs.

You can get cooperation by tax amortization and writeoffs and subsidization. I commend industry for what they have done. We are proud of their achievement. But I think we should put on the record we would not have had this advance without appropriations to the program and without the encouragement and the drive and the leadership of the Atomic Energy Commission.

Let us be thankful also, that we have men with imagination and drive, forward looking men, who are not looking just for the profit motive alone, just the dollar alone, that they will make out of the sale of coal or the sale of power.

There have been those who in my opinion have tried to slow the program down. Let us commend industry but let us not say that industry has done this job entirely.

Admiral RICKOVER. May I comment?

Mr. EVINS. Yes, I wish you would.

Admiral RICKOVER. In my dealings with industry for many years I have found that, by and large, if they understood what we were trying to do they would do a great deal to help. That has been my experience. Of course, you cannot expect every industrial organization to be perfect at all times, particularly when the definition of perfection is set by yourself.

You cannot do that. Let me give you an example: Two weeks ago I visited a large shipbuilding company. Their general manager told me that many of the items received in that large shipyard have defects in them, and this after the inspection that had been given them by industry inspectors and by Government inspectors.

Many of the important items that came in at the yard were in some way or other defective. This has been my general experience throughout the naval and Shippingport programs. So here is an area where industry can improve very much. I think this is where we are falling down as a Nation: we think we are so much better than everybody else that we do not realize that a great deal of sloppiness has entered into many of our organizations. I do not mean items that we produce on an assembly line. I am referring to items that are unusual and difficult to manufacture. The genius in building up an atomic powered Navy or atomic central stations is to have industry elevate itself to a far greater height than they are now. They will have to improve their management and technical standards.

In my opinion one of the reasons we are having so much trouble in the missile program and so many failures, is because of the lack of attention to many small details, particularly by management. They run

their jobs too often from plush offices; they do not know, except from hearsay, what is going on.

Mr. EVINS. Many industries would not have gone forward without the aid of Congress and they have so indicated that.

Admiral RICKOVER. There is no question about that, sir. Without the continued financial support of the Government they could not have. It is my opinion that Congress is supporting industry too much, particularly the aviation industry where nearly all of the facilities have been paid for by the Government. I think there should be an attempt to get industry itself to pay for some of these facilities.

Mr. EVINS. No doubt there are certain special interests, profit interests, monopoly interests, that are not anxious to see this great scientific development go forward at the rapid rate and speed others would like to see. They would prefer that it be slowed down.

Admiral RICKOVER. I doubt that, sir. I would doubt that. I am sorry I do not agree with you on this point.

Mr. EVINS. Well, it is all right for us to part company. We all admire you and all the members of the Commission. My emphasis is that we not have a slowdown, that we not stall on dead center but that we go forward.

Admiral RICKOVER. You know that I say what I think; I may be wrong, but in my work I have not seen any attempt at slowdowns, sir.

Mr. EVINS. I admire this Commission and this great staff and it is in your hands that our security lies and I want to commend you for your great achievements, all of you.

That is all.

Mr. CANNON. Dr. Fenton?

Mr. FENTON. Admiral Rickover, this is the first time I have had the pleasure of meeting you and I have enjoyed every minute of it. I am certainly happy to note the fine cooperation that you are enjoying from the various members of the Commission, with the Congress, and of course, with private industry.

I am very glad to hear you make the statement that you do not make progress by spending money. That is true, as you say, with respect to all kinds of research. It is certainly true not only in the atomic energy field, but also in the field of medical science which I happen to know something about.

Of course, that is where the trouble comes in, trying to help out where industry cannot do the job. I know you are dedicated to the atomic energy field, particularly the Navy end of it.

NUCLEAR SUBMARINES

Mr. Jensen asked you something about the relative merits of nuclear submarines versus the conventional type and you said that you would get far better protection by the atomic type submarine. I gathered from your answer you meant the fuel part of it and the speed that is generated. Is that the only reason?

Admiral RICKOVER. Yes, sir. The speed and the endurance. We could not make speeds as high as we do in a submarine unless it were nuclear powered. The submarine would become way too large, otherwise. Of course, the endurance of the conventional submarine is

strictly limited. We get practically unlimited endurance and much higher speed in the nuclear submarine.

Mr. FENTON. That is what I gathered. Therefore, we would not need as many submarines.

Admiral RICKOVER. That is right, sir. To perform a given mission we would not need as many.

Mr. FENTON. A lot was said—particularly in our report of the Armed Services Committee on Appropriations—about that particular item, the submarine item, and which as you verified here today, that had Germany, I think you said, 10 submarines, atomically driven, that they probably would have won the war.

Admiral RICKOVER. We made an estimate several years ago; it turned out that about 10 nuclear submarines could keep the Atlantic Ocean swept of surface traffic.

Mr. FENTON. How many atomic energy submarines do you think we would need to combat the Russian menace if what they say is true?

Admiral RICKOVER. Today we have a total of 110 or 120 submarines in operation, of which 5 are nuclear powered. The role of the submarine is changing from commerce destruction to two other functions: One, to preserve the supply lines to Western Europe, which would be heavily attacked by Russian submarines; the other, the POLARIS, the strategic-type submarine. The POLARIS type will carry missiles; it will be able to hide out under the polar icecap and in other seas; it will constitute a threat to the Russians in the event they ever dare to attack us. Because no matter what they did to us, these submarines would remain fleets in being. They would be there and the Russians would know that they themselves must inevitably be destroyed if they dared attack us. This is what Mr. Cannon was referring to earlier in his statement, that he thought the POLARIS might be the best weapon system we have for protecting this country, because it would be our best deterrent.

ADEQUACY OF 1960 ESTIMATE

Mr. FENTON. Now, coming back to the 1960 estimates as they affect you, Admiral, do you think that the amount budgeted for your particular jurisdiction is enough?

Admiral RICKOVER. Yes, sir, it is enough and I hope to save some.

Mr. FENTON. You would not, however, like to have that amount cut?

Admiral RICKOVER. I assure you, sir, that I will not spend any money unless I consider it is worthwhile. There have been numerous occasions in the past where I have had money authorized but which I have not spent. I assure the committee that no matter what sum you appropriate for my work I will not waste it. My AEC budget is ample, I am being well taken care of; I have no complaint. The Atomic Energy Commission is quite generous to me. I hope you do not cut any of my funds at this time, though.

Mr. FENTON. That is just the question I asked you.

Admiral RICKOVER. I hope you do not cut it and that you will give me this leeway. I assure you it will not be wasted. I hope I will be able to save some. I would like to make this gentlemen's agreement

with you: I think you know from previous years that I have not asked for money I did not need or violated your confidence in this respect.

Mr. FENTON. Thank you very much, Admiral. I appreciate your frankness.

Mr. CANNON. Thank you, Admiral.

Are there further questions?

Thank you, Admiral Rickover. We very much appreciate having you with us this afternoon. We greatly appreciate the testimony which you have given the committee. We hope that whenever you have any recommendations to make that you will give us the benefit of them.

Admiral RICKOVER. Please don't let people ax us now just because I have made some frank statements. I have been honest with you. You would not want me to come in next year and ask for twice as much?

Mr. MCCONE. I would like to say that the Commission very carefully reviewed this item in the budget after long and searching examination by Admiral Rickover and his staff.

We are satisfied this represents the appropriate amount of money to recommend to you for appropriation for this area of activity for the year. I think it is a very well considered and carefully developed budget.

Mr. CANNON. Admiral Rickover, you may be dismissed at this time or you may stay with us as you prefer. We are very grateful to you for giving us your time.

Admiral RICKOVER. Thank you, sir.

REACTOR DEVELOPMENT

Mr. CANNON. Mr. Chairman, taking up the estimate for reactor development, which we have just been discussing indirectly, in this instance a recommendation of $407.4 million, and I shall ask the stenographer to insert pages 50 through pages 110. What specific progress, Mr. Chairman, in the development of economic electric power can you cite that has taken place since our hearings last year?

(The document follows:)

REACTOR DEVELOPMENT PROGRAM, OPERATING COSTS

Program statement

Estimate fiscal year 1960	$407,400,000
Estimate fiscal year 1959	342,000,000
Increase	65,400,000

The reactor development program includes the development of economically feasible nuclear powerplants for civilian power and commercial ship application, Euratom program, and development of reactors and reactor systems to meet a wide range of military requirements. Briefly stated, the objectives in the separate activities are—

CIVILIAN POWER REACTOR PROGRAM

1. To achieve safe, reliable, and economically competitive production of electric power from reactors in the United States within the next decade.
2. To help Euratom nations and other countries effect a speedy transition to nuclear power.
3. To establish a complete and sound technological base for a future atomic energy industry.

ENGINEERING DEVELOPMENT AND APPLIED FUEL CYCLE PROGRAM

1. To provide broad support for civilian, maritime, and military reactor programs through the development of materials, moderators, control techniques, reactor safety, separation systems, and waste disposal procedures.
2. To develop, manufacture, and test fuel elements in order to reduce nuclear power costs.

MERCHANT SHIP REACTORS

1. To demonstrate the practicality of nuclear-powered merchant ships.
2. To develop nuclear propulsion systems which can compete economically in world commerce.
3. To insure safe operation of nuclear-powered merchant ships and their acceptance in world commerce.

MILITARY REACTORS

1. To develop land-based reactor systems to meet military requirements for powerplants for use in remote areas and for unique military purposes.
2. To develop nuclear propulsion plants suitable for installation in naval vessels ranging from small submarines to large surface ships.
3. To develop nuclear propulsion plants for propulsion of manned aircraft.
4. To determine the feasibility of nuclear application in missiles and satellites and to develop those applications deemed feasible.

The increase of $65.4 million in fiscal year 1960 over fiscal year 1959 is principally due to new enlarged programs, related as follows:

1. An increase of $19.5 in civilian power program primarily for boiling water, fast power breeder, sodium graphite, organic moderator, gas-cooled and heavy water concepts, and for experiment fabrication, and a sizable decrease in fluid-fuel reactors.
2. An increase of $2.9 million in reactor systems R. & D. primarily in reactor fuels and materials development and for advanced testing and research reactors; an increase of $4.2 million for reactor safety primarily for SPERT activities, including initiation of fabrication of SPERT IV experiment; and an increase of $1.3 million in radioactive residues management.
3. An increase of $7.0 million in applied fuel cycle development program.
4. An increase of $1.2 million in the merchant ship reactor program primarily for a first replacement core for the N.S. *Savannah*.
5. An increase of $23.3 million in military reactor categories for further expansion in support of the Department of Defense requirements.
6. Initiation of Euratom program of $5.0 million.
7. An increase of $3.5 million for design and engineering studies.
8. Adjustments in other categories reflect a net decrease of $2.6 million.

Summary of estimates by category

Category	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
1. Civilian power reactors:			
(a) Government program	$70,833,480	$75,020,000	$90,100,000
(b) Cooperative arrangements program	7,234,447	15,200,000	19,595,000
Subtotal	78,067,927	90,220,000	109,695,000
2. Design and engineering studies	1,078,000	1,500,000	5,000,000
3. Euratom program	0	0	5,000,000
4. Reactor systems research and development	13,434,418	14,800,000	17,700,000
5. Fuel cycle development	0	6,000,000	13,000,000
6. Reactor safety	6,413,268	5,500,000	9,700,000
7. Separations systems development	7,474,607	5,200,000	6,000,000
8. Radioactive residues management	2,975,498	3,200,000	4,500,000
9. Merchant ship reactors	1,545,862	4,800,000	5,990,000
10. Army power reactors	5,377,388	9,100,000	11,000,000
11. Naval propulsion reactors	90,195,816	86,000,000	90,000,000
12. Airplane propulsion reactors	62,221,581	65,800,000	68,700,000
13. Missile propulsion reactors	12,054,706	21,000,000	27,900,000
14. Satellite power sources	3,437,113	7,500,000	12,100,000
15. Operational services	5,915,471	3,380,000	1,300,000
16. Equipment	18,769,980	18,000,000	19,815,000
Total, reactor development program	308,961,635	342,000,000	407,400,000

JUSTIFICATION OF CATEGORIES

1. Civilian power reactors, $109,695,000—(a) Government program

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
(1) Pressurized water reactor	$17,462,222	$17,000,000	$20,000,000
(2) Boiling water reactor	3,699,350	4,038,000	8,200,000
(3) Fluid fuel reactors	21,436,691	19,700,000	7,500,000
(4) Fast power breeder reactor	7,408,942	10,254,000	12,100,000
(5) Sodium graphite reactor	7,166,015	6,500,000	8,750,000
(6) Organic moderator reactor	5,102,446	2,817,000	5,800,000
(7) Plutonium recycle program	3,470,193	4,800,000	5,000,000
(8) Heavy water reactor	1,890,539	3,750,000	6,250,000
(9) Gas-cooled power reactor	2,500,011	5,050,000	9,500,000
(10) Advanced design studies	697,071	1,111,000	2,000,000
(11) Experiment fabrication	0	0	5,000,000
Total	70,833,480	75,020,000	90,100,000

During fiscal year 1960 seven AEC-owned power reactors and power reactor experiments will be in operation. These are the Shippingport atomic power station, boiling reactor experiment–5 (BORAX–V), boiling water reactor experiment (EBWR), experimental breeder reactor–1 (EBR–I), sodium reactor experiment (SRE), organic moderator reactor experiment (OMRE), and experimental breeder reactor–2 (EBR–2). Two test reactors will be in the late stages of development or under construction. These are the plutonium recycle test reactor (PRTR), and the heavy water components test reactor (HWCTR). The experimental gas-cooled reactor (EGCR) which will begin construction in early fiscal year 1960 is to be used extensively in the development of advanced fuels and materials. Following an evaluation of the fluid fuel reactor program, it was decided that none of the concepts will be supported beyond fiscal year 1959 as an approach to the achievement of economic nuclear power. During fiscal year 1960 a transition will be made from the present fluid fuel program to a thermal breeder reactor program. It is expected that the molten salt and liquid metal fuel reactor projects will be closed out in fiscal year 1960.

(1) Pressurized water reactor

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Total	$17,462,222	$17,000,000	$20,000,000
Research and development	16,611,643	13,465,000	9,000,000
Fuel fabrication	595,913	2,135,000	9,000,000
Test operations	254,666	1,400,000	2,000,000

The Shippingport atomic power station is the country's first full-scale nuclear central station powerplant. The plant was constructed with the primary objective of obtaining reactor plant and core test information and of advancing general reactor technology. Realistic information relative to the design, operation, and maintenance of central station nuclear powerplants can be obtained from full-scale test operations inasmuch as the plant must also function as a practical commercial power producer capable of sustaining its design load under conditions imposed by operation of an electric utility network.

The Shippingport reactor achieved criticality on December 2, 1957. Initial plant tests were conducted during the balance of fiscal year 1958. Fiscal year 1959 will be the first full year of test operations and plant evaluation. During fiscal year 1959 development of plate-type uranium oxide fuel elements for core 2 will continue, and irradiation tests and critical experiments will be conducted. It is anticipated that core 2 will be suitable for generating approximately 150 megawatts gross of electricity as contrasted to 60 megawatts net for core 1 and will have a significantly longer life than core 1. Present developments indicate that uranium oxide plate fuel elements can be operated at higher heat fluxes than uranium oxide rods of any practical size and to higher burnups than

uranium zirconium plates, thus increasing both core power density and core life. Other factors which it appears will contribute to the increased power capabilities of PWR core 2 include the differential radial fuel loadings in both the seed and blanket which improve the uniformity of power generation within the core, and the utilization of lumped burnable poisons so as to minimize local power peaking in the core. Through the use of lumped burnable poisons the mechanical reactivity control of the core is also simplified. In addition, PWR core 2 will have about 50 percent more instrumentation than that incorporated in PWR core 1. This is especially significant in view of the importance of getting as much information as possible on the high performance uranium-oxide plate type fuel elements which will be used in this core. During fiscal year 1959 fabrication of seed 2 for core 1 will approach completion.

Research, development, and fabrication of improved cores will continue during fiscal year 1960. During fiscal year 1960 seed 1 of the initial core will be removed and replaced with seed 2. At the same time one or more blanket fuel bundles will be removed from the reactor for study of plutonium buildup and metallurgical changes. These blanket assemblies will be replaced with spares. Critical experiments, work on lumped burnable poisons, and fuel and reactor material irradiation tests will be continued in the final development effort for core 2. A study will be made of the thermal performance of seed 2 for core 1, and the information gained through this analysis will be used in improving future designs of advanced type cores. Models will be built and tests conducted to verify various mechanical, thermal, and hydraulic core design characteristics. Fabrication work will begin on core 2 and seed 3, core 1.

During fiscal year 1960 the results of tests and operation of the plant will continue to be analyzed. Plant and core evaluation studies will be prepared for distribution by the AEC ot private industry and educational institutions, and plant and reactor cost reduction studies will continue. Duquesne Light Co. will continue to be reimbursed in accordance with its contract for costs incurred in operation, maintenance, and tests of the nuclear portion of the plant.

(2) Boiling water reactors

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Total	$3,699,350	$4,038,000	$8,200,000
Research and development	2,789,988	3,201,000	6,430,000
Fuel fabrication	0	100,000	770,000
Test operations	610,056	737,000	1,000,000
Experiment fabrication	299,306	0	0

Boiling-water reactors are one of the major contenders for early achievement of economic nuclear power because of their inherent simplicity. The Commission's basic development work on this concept, centered at the Argonne National Laboratory, will be expended and diversified during fiscal year 1959 to include one or more industrial contractors. Benefit should be derived from private contractors' incentive for cost reductions and experience in adapting boiling-water reactors to large commercial powerplants. The major facilities in this program are the EBWR, BORAX, and industrial facilities.

Modification of the EBWR has been initiated in fiscal year 1959 with the installation of additional heat-dissipation equipment, thus permitting operation at 100 MWT. BORAX IV modifications consist largely of replacing the pressure vessel, core, core support, and piping as required to permit operation at 600 p.s.i. and 40 MWT. This modified facility will henceforth be known as BORAX V. Modification of these two facilities is scheduled for completion late in fiscal year 1961.

The primary development effort continues to be at Argonne National Laboratory. Increasing development effort will be undertaken by one or more industrial contractors to be selected in late fiscal year 1959. Argonne National Laboratory will continue basic research and development on metallurgy, controls, components, and fuel elements. Activities by industrial contractors during fiscal year 1960 will include engineering development work in such fields as heat transfer, fluid dynamics, metallurgy, physics, and inpile loop tests. This work will be necessary to establish the design of the high-performance core to be

installed in an existing boiling-water reactor. Additional metallurgical investigations will be conducted as required in support of the inpile loop tests. A breakdown of research and development costs is as follows:

	Estimate fiscal year 1959	Estimate fiscal year 1960
Argonne National Laboratory basic research and development on metallurgy, controls components, fuel, element and superheat	$2,323,000	$3,890,000
New contractors	608,000	2,260,000
Irradiation services	270,000	280,000
Total	3,201,000	6,430,000

The following new cores will be required for operation of the EBWR and BORAX reactors:

	Estimate fiscal year 1959	Estimate fiscal year 1960
EBWR core 2	$100,000	$500,000
BORAX V core 1	0	270,000
Total	100,000	770,000

EBWR and BORAX operations will resume after completion of modifications during the first quarter of fiscal year 1960. The primary objective of the EBWR operations will be to determine the stability limit at which power can be produced in this plant. The BORAX V facility will be used to evaluate promising integral nuclear superheater core arrangements, various moderator-to-fuel ratios, and the relative merits of natural and forced circulation. Advanced studies will continue in fiscal year 1960 on such concepts as variable moderator reactor, boiling UO_2 slurry reactor, etc.

(3) Fluid fuel reactors

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Total	$21,436,691	$19,700,000	$7,500,000
Aqueous homogeneous reactor	11,965,561	9,600,000	5,000,000
Molten salt reactor	2,483,329	2,700,000	1,000,000
Liquid metal fuel reactor	6,987,801	7,400,000	1,500,000

During fiscal year 1958 and fiscal year 1959 three fluid fuel reactor concepts have been under active development:

(*a*) Aqueous homogeneous reactors using a heavy water-based solution or slurry of thorium and uranium.

(*b*) Molten salt reactors using complex fluoride based salts containing uranium and thorium as the fuel and fertile material.

(*c*) Liquid metal fueled reactors with a bismuth-uranium alloy of low melting temperature as the fuel and thorium slurry in bismuth as a blanket.

In its report to the Commission in December 1958, an Ad Hoc Committee on Reactor Policies and Programs recommended that the fluid fuel concepts be critically evaluated and work concentrated on the concept that appeared most promising. Subsequently a task force of outstanding scientists and engineers was convened to make this technical evaluation and comparison in January 1959. The findings of the task force were used to evaluate each of the fluid fuel concepts in terms of its potential for meeting the objectives of the national civilian power reactor program. It was concluded that (1) none of the fluid fuel concepts can meet the short-term objectives of achieving competitive power costs in the United States in 10 years or in foreign countries in 5 years; (2) none of the fluid fuel concepts are potentially attractive for reducing power

costs in the long range based upon task force estimates of power costs for 300 Mw(E) stations and of the R. & D. program required to achieve technical feasibility; and (3) the aqueous homogeneous reactor has a strong potential for successful development as a thermal breeder with a doubling time of about 15 years, and therefore merits consideration under the objective of extending nuclear fuel resources through the development of breeder reactors. Because of the long doubling times of the liquid metal fuel reactor and molten salt reactors, these systems are of only marginal value and interest as thermal breeders.

Based on these conclusion, the following decisions have been made with regard to the fluid fuel program:

(1) None of the fluid fuel concepts will be supported beyond fiscal year 1959 as an approach to the achievement of economic nuclear power;

(2) The Oak Ridge National Laboratory has been assigned responsibility for a long-range program directed to the development of a thermal breeder reactor having a doubling time of not more than 25 years.

(3) During fiscal year 1960 a transition will be made from the present fluid fuel program to the thermal breeder reactor program. Budget allocations shown above reflect this transition and assume continuation of work on the aqueous homogeneous project throughout fiscal year 1960 and closeout of both the molten salt reactor and liquid metal fuel reactor during this period.

The thermal breeder reactor program is envisioned as a long-term stable effort. Its initial phases will be characterized by basic research and development work and evaluation studies to determine the most promising type of thermal breeder for continued development.

(4) *Fast power breeder reactor*

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Total	$7,408,942	$10,254,000	$12,100,000
Research and development	6,586,982	8,769,000	9,330,000
Fuel fabrication	387,584	867,000	970,000
Test operations	387,720	618,000	1,800,000
Reactor experiment fabrication	46,656	0	0

The primary objective of the Commission's fast breeder program is to develop the technology of fast reactors to a point where they are practical for commercial power production. Effective long-range utilization of nuclear fuels will require reactors that breed more fissionable material than they consume. To date, only fast reactors have demonstrated the ability to breed. Two other important phases of the fast reactor program are the development of a practical pyrometallurgical process for reprocessing fast reactor fuel and research on fast reactor safety.

The major facilities in the fast reactor program are: (*a*) The EBR–1 which is used for safety examinations and general fast reactor research; (*b*) EBR–2 which is presently under construction and scheduled for initial operation in May, 1960; (*c*) the ZPR–3, now operable, and the ZPR–6, which has been designed, will be constructed for critical experiments and other physics tests, and (*d*) the TREAT reactor for test meltdown of fuel elements as part of the safety program.

The major effort at the Argonne National Laboratory is on the design, development, construction, and operation of EBR–2, the prototype of a complete fast reactor plant for the production of power. Particular emphasis is being placed on the following: The development of a high performance fuel element which will operate at high temperatures and permit high burnup; the development of suitable, large liquid metal coolant system components; and the development of an economical reactor complex including fuel handling, reprocessing, and refabrication. EBR–2 wil duplicate the more critical operating conditions anticipated in a large reactor, such as coolant temperature, heat flux, neutron flux, coolant velocity, and power density. Since it is fundamentally an experimental reactor, flexibility of operation and reactor loading are required to permit improvements in performance. Completion of the reactor and power

system is scheduled for May 1, 1960. The detailed analyses of systems performance have continued with emphasis on reliability and self-protection under all anticipated reactor conditions. The injection casting process for the first uranium loading of EBR–2 has been developed further and irradiation tests on the fuel elements will continue. The detailed testing of the remote assembly, disassembly, and processing of fuel is continuing with very promising results to date. The testing and evaluation of the coolant system components continues actively. Fabrication of the first core of the EBR–2 will be started in fiscal year 1959 and completed in fiscal year 1960. The increase in test operations shown for fiscal year 1960 is to train personnel and prepare for critical tests of the EBR–2 in late fiscal year 1960.

Operation of EBR–1 with a Mark III rigid core, which was subsequently modified to a nonrigid form, provided data for determining the effect of bowing of fuel rods on the reactivity of the core. Analysis of these data will be underway at the close of fiscal year 1959. The EBR–1 will be operated throughout fiscal year 1959 and fiscal year 1960.

The transient reactor test facility (TREAT), first critical in February 1959, is in its initial phase of operation leading to meltdown experiments of fast reactor fuel pins in the absence of sodium. During fiscal year 1960, the experimental meltdown program will continue, with the experiments progressing to more complicated arrays of fuel pins in both flowing and nonflowing sodium.

(5) Sodium graphite reactors

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Total	$7,166,015	$6,500,000	$8,750,000
Research and development	6,012,592	4,800,000	6,225,000
Fuel fabrication, SRE	0	215,000	585,000
Test operations, SRE	1,153,423	1,485,000	1,940,000

The SRE which was completed in late fiscal year 1957, will be operated throughout fiscal year 1958 and fiscal year 1959. This reactor experiment has been progressively developed and improved to overcome the many difficult problems associated with sodium systems and has demonstrated that there are no insurmountable problems to prevent this concept from realizing the potential advantages which can come from production of high temperature steam in a low pressure system. The operation of the SRE will continue in fiscal year 1960 and a newly designed core will be installed. This new core design should permit operation at higher temperatures with reduced moderator can stress and better neutron economy.

A program to develop improved nonuclear components for sodium systems has been initiated. It is essential that the cost of such components be reduced and their reliability improved if this type plant is to be competitive with conventional systems. These improved sodium components can be used with sodium cooled fast breeder reactors as well as with sodium graphite reactors.

Continued analysis and evaluation of the SRE, examination of irradiated fuel elements and studies on long term reactivity changes will constitute a major portion of the development effort in fiscal year 1959 and fiscal year 1960. Extensive irradiation and hot cell examination of promising fuel materials will be conducted. Investigations of structural and component materials will be continued to permit the attainment of higher performance levels.

A second fuel loading of a thorium uranium allow will be completed in fiscal year 1959 for the SRE. This material is more resistant to irradiation damage and should permit higher temperature operation and longer fuel life. Fabrication of a third more advanced fuel loading of uranium-carbide will be initiated in mid-fiscal year 1960.

Advanced studies will continue in fiscal year 1960 to improve the mechanical arrangements, nuclear characteristics, and economies of full scale, sodium-cooled graphite moderated powerplants. During fiscal year 1959, an advanced 250 MWE plant was designed which was based on the use of a calandria core and uranium-carbide fuels. Studies in fiscal year 1960 will concentrate on simplifications in the coolant flow path and mechanical arrangements of the basic design prepared in fiscal year 1959.

The schedule of costs for these cores is as follows:

	Estimate, fiscal year 1959	Estimate, fiscal year 1960
SRE core 2, Th-U	$215,000	0
SRE core 3, UC	0	$585,000
Total	215,000	585,000

During fiscal year 1960, operation of the SRE at high-power levels will be continued to obtain additional information on operating characteristics of the system. Development, installation, and testing of improved components will be continued. The increased cost shown for test operations in fiscal year 1960 is to provide for a larger operating and maintenance staff to permit more detailed measurements and analysis of the characteristics of the new core loading. This increase also will permit more expeditious maintenance on the system and thereby decrease the down time of the plant.

(6) Organic moderator reactor

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Total	$5,102,446	$2,817,000	$5,800,000
Research and development	4,201,821	1,617,000	4,220,000
Fuel fabrication	106,049	790,000	170,000
Test operation	794,576	1,[illegible]0,000	1,410,000

Organic reactors hold promise of low capital cost because the low pressure, noncorrosive, and low radioactive characterisitcs of the coolant permit use of relatively simple and inexpensive components outside of the active core area. The OMRE was designed as a minimum cost project with limited scope for investigation of organic fouling and decomposition. Operation of the OMRE has satisfactorily resolved uncertainties on these matters. Therefore, a major increase in effort on organic moderator reactors is warranted to develop better organic coolants, and investigate alternate moderators to fully evaluate the potential of this system.

The major areas of research and development required on organic reactors relates to heat transfer characteristics. Any increase achieved in the rate of heat transfer will directly reduce the unit capital cost. Heat transfer is dependent on organic coolant characteristics and core design.

Atomics International will continue organic coolant work and studies on core evaluations. New contractors specializing in organic materials have been selected in fiscal year 1959 to augment this work. A major portion of the research and development effort will be for advanced organic reactors. Atomics International will also continue general research and development on metallurgy, controls, fuel elements, and components related to test operation of the OMRE.

The breakdown of the research and development effort is as follows:

	Estimate fiscal year 1959	Estimate fiscal year 1960
Atomics International	$1,200,000	$2,020,000
New contractor, organic materials	100,000	300,000
Advanced organic reactor development	317,000	1,900,000
Total	1,617,000	4,220,000

The scheduled operation of the OMRE requires completion of cores 2 and 3 in fiscal year 1959 and core 4 in fiscal year 1960, with costs distributed as follows:

	Estimate fiscal year 1959	Estimate fiscal year 1960
Core 2	$50,000	0
Core 3	150,000	0
Core 4	0	$170,000
Total	200,000	170,000

The OMRE will be operated throughout fiscal year 1960 and additional manpower will be used in the analysis of the data and to collect additional information which is not now obtainable. The reactor will be operated with various combinations of organic temperature, power level, and concentration of polymerized organic material in the coolant to study the organic decomposition rates and the optimum operating conditions. After reactor modification, to be completed in fiscal year 1960, a different organic material will be used in the reactor to study its decomposition rate as a function of different operating conditions. In fiscal 1960, the continuous evaluation of new reactors will continue with emphasis placed on OMR plants with variable lattice spacing, solid moderators, and nuclear superheat.

(7) *Plutonium recycle program*

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Total	$3,470,193	$4,800,000	$5,000,000
Research and development	3,470,193	4,223,000	4,200,000
Fuel fabrication	0	577,000	800,000

The plutonium recycle program at the Commission's Hanford works is designed to assist in developing technology applicable to the use of plutonium as fuel in several types of thermal heterogeneous power reactors.

Recycling plutonium in thermal reactors is particularly important to nations possessing supplies of natural uranium but lacking in facilities for enriching uranium. Using natural uranium as the basic fuel in reactors in combination with recycled plutonium will make possible compact, high-performance, enriched reactor systems.

During fiscal year 1959, construction will continue on the Plutonium Fabrication Laboratory to provide a facility to develop and fabricate plutonium-bearing fuel elements, and on the plutonium recycle test reactor to test the fuel elements and demonstrate the feasibility of the plutonium recycling process in thermal heterogeneous reactors. Both facilities are scheduled for completion during fiscal year 1961; however, initial beneficial occupancy of the laboratory is scheduled for August 1959 which will accelerate the development and evaluation of fuel designs and fabrication processes for spiked fuel elements.

During fiscal year 1960 emphasis will be directed toward: (*a*) the design, fabrication, and evaluation of uranium fuel elements uniformly alloyed with plutonium; (*b*) studies of ceramic fuel materials capable of operating at higher temperatures; (*c*) laboratory testing of irradiated fuel prototypes; and (*d*) the integration of fuel development with the separation process programs. Activities will continue in the development of higher strength and less corrosive process tubes and fuel jacket tubing, with emphasis on reducing fabrication costs. A method of processing PRTR fuels will be developed. Through research on low-cost, close-coupled processing methods, flow sheets will be established leading to scaled-up studies in engineering prototype equipment. Development will begin on an experimental-theoretical program which will result in reliable reactor physics formulas that can be used to predict the design and

operating characteristics of reactor operating with recycled plutonium. Tests of reactor components will be completed and testing and startup tests of the PRTR will be initiated late in fiscal year 1960. Training of a complete reactor operating force will also get underway during fiscal year 1960.

Fabrication of the first core loading will be started in fiscal year 1959 and completed in fiscal year 1960.

(8) Heavy water reactor

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Total	$1,890,539	$3,750,000	$6,250,000
Research and development	1,890,539	3,250,000	5,950,000
Fuel fabrication	0	500,000	300,000

The heavy water reactor program which was initiated early in fiscal year 1957 at the Savannah River plant to meet the increasing demands for a power reactor utilizing natural uranium as fuel, will continue throughout fiscal year 1960. The program involves design, development, construction, and operation of a heavy water components test reactor (HWCTR).

The major effort is being directed toward the development of technological data to support the design and construction of the heavy water components test reactor under construction at Savannah River. The HWCTR will contain enriched uranium driver fuel elements and natural uranium fuel elements.

The fuel element development program will receive major emphasis, with new subcontractors assisting in the development of suitable fuel elements and in improving the quality and decreasing costs of a long-life natural uranium element. Similar efforts will be carried out on the enriched driver elements which will be used in the HWCTR. Studies and development work will be done on the possible use of oxide elements as a backup fuel. Work will also continue on the fabrication and testing of zirconium and its alloys.

Reactor engineering work will continue on the test reactor and will include work on hydraulic charcteristics of fuel element assemblies in the pressurized flow test facility; heat transfer studies; irradiation testing of materials of construction and system components, including instrumentation and control devices; and design and evaluation of pumps, valves, and other equipment.

Design of the first core configuration for the HWCTR will be frozen, materials ordered and fabrication initiated in fiscal year 1959. The core will be completed in fiscal year 1960.

The HWCTR operating crew will be selected and trained during fiscal year 1960 in anticipation of reactor startup in fiscal year 1961.

(9) Gas-cooled power reactor

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Total	$2,500,011	$5,050,000	$9,500,000
Research and development	2,500,011	5,050,000	9,500,000

Extensive design and engineering studies undertaken over the past few years have determined that gas-cooled reactors show potentialities for early development as economical power producers. The experimental gas-cooled reactor (GCR) which will begin construction in early fiscal year 1960, is to be extensively used in the development of advanced fuels and materials.

In fiscal year 1960, Oak Ridge National Laboratory will continue to work on developing and testing fuels and reactors materials for the EGCR. This development effort will include an extensive metallurgy program, operation of in-pile loops and a program to develop lower cost methods of fabricating ceramic fuel elements.

Kaiser-ACF will continue development work in fiscal year 1960 in specific support of the EGCR.

Hanford will continue research and development work on graphite technology and reactor physics.

The estimated fiscal year 1959 and fiscal year 1960 research and development costs follow:

	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Oak Ridge National Laboratory	$1,000,000	$6,030,000
Hanford	300,000	1,370,000
Kaiser Engineers	3,750,000	2,100,000
Total	5,050,000	9,500,000

(10) Advanced design studies

Fiscal year 1958	$697,071
Fiscal year 1959	1,111,000
Fiscal year 1960	2,000,000

The two main areas of work involved in this program are:

(*a*) Technical and economic evaluation of new reactor concepts involving the performance of computational analysis, special research investigations, investigations of various economic aspects of civilian nuclear and conventional power which are relevant to nuclear power development, the performance of integral experiments as necessary to establish the feasibility and promise of the reactor system, and the determination as to the desirability or timing of proceeding with the building of the reactor.

(*b*) Performance of advance design studies on various reactor concepts, involving analysis of physics experiments, fuel and materials properties, heat transfer experiments, fluid flow experiments, coolant chemistry, reactor safety, components and auxiliary systems, and the preparation of a conceptual design report.

(11) Experiment fabrication

Fiscal year 1958	0
Fiscal year 1959	0
Fiscal year 1960	$5,000,000

The research and development phase of the reactor development program leading to a plant producing commercially competitive power will include the fabrication of critical and reactor experiments. The exact concepts for which these will be fabricated will depend upon the advancement of the technology. However, examples of the types of experiments to begin fabrication in fiscal year 1960 are pebble beds, variable moderated, fluidized beds, etc.

(b) Cooperative arrangements program

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Yankee Atomic Electric Co	$2,156,182	$1,400,000	$225,000
Fast reactor systems	472,384	300,000	600,000
Consumers Public Power District	2,463,671	5,500,000	4,268,000
Rural Cooperative Power Association	0	0	100,000
City of Piqua, Ohio	55,215	2,800,000	337,000
Chugach Electric Association of Alaska	1,584,553	2,218,000	0
Northern States Power Co	502,442	1,300,000	2,500,000
Carolina-Virginia nuclear power group	0	1,182,000	2,600,000
East central and Florida west coast nuclear power groups	0	500,000	2,165,000
Boiling-water prototype	0	0	850,000
Intermediate size reactors	0	0	1,350,000
Unsolicited proposals	0	0	1,500,000
Philadelphia electric	0	0	3,100,000
Total	7,234,447	15,200,000	19,595,000

On January 10, 1955, the Commission announced its power reactor demonstration program and issued its first invitation to industry to submit proposals for the design, development, construction, and operation of demonstration

nuclear powerplants. Since that date two additional invitations have been issued. New proposals for cooperative arrangements will be considered in accordance with the criteria set forth in the fiscal year 1960 authorization act.

Yankee Atomic Electric Co.:

Fiscal year 1958	$2,156,182
Fiscal year 1959	1,400,000
Fiscal year 1960	225,000

Research and development on this project will be essentially completed by mid-fiscal year 1960. Operation is now scheduled for early fiscal year 1961.

Fast reactor systems:

Fiscal year 1958	$472,384
Fiscal year 1959	300,000
Fiscal year 1960	600,000

It is planned to continue throughout fiscal year 1960 to provide research and development assistance to industrial sponsored fast breeder power reactors. This support work will be incremental to the fast breeder technology activity in the Government base program and will be carried out primarily in AEC facility. Consulting service, critical experiments, and irradiation services and fuel studies will be the principal services performed.

Consumers Public Power District:

Fiscal year 1958	$2,463,671
Fiscal year 1959	5,500,000
Fiscal year 1960	4,268,000

As component designs are frozen and testing is completed, research and development emphasis will be reduced in fiscal year 1960 from the fiscal year 1959 level. It is planned that the nuclear portion of the facility will be under cover by December 1960, with construction completed in mid-fiscal year 1962. Arrangements under the project call for AEC preoperational research and development assistance estimated at $18,165,000 and $8 million postoperational assistance to provide for operating losses incurred by Consumers Public Power District as a result of unusual maintenance and excess fuel costs.

Rural Cooperative Power Association:

Fiscal year 1958	0
Fiscal year 1959	0
Fiscal year 1960	$100,000

Costs incurred are for postconstruction research and development, and administrative expenses as provided for in the contract with RCPA.

City of Piqua, Ohio:

Fiscal year 1958	$55,215
Fiscal year 1959	2,800,000
Fiscal year 1960	337,000

Development emphasis in fiscal year 1960 will be limited primarily to fuel element irradiations and subsequent hot-cell examinations and evaluation. Detailed design beginning in late fiscal year 1959 will allow for plant construction to start in early 1960 with completion scheduled for early fiscal year 1961.

Chugach Electric Association of Alaska:

Fiscal year 1958	$1,584,553
Fiscal year 1959	2,218,000
Fiscal year 1960	0

The Commission has decided that the sodium deuterium reactor will not be constructed at Anchorage, Alaska, as previously planned under the power demonstration program. The Commission is considering the possibility of constructing another reactor type at the Chugach site.

Northern States Power Co.:

Fiscal year 1958	$562,442
Fiscal year 1959	1,300,000
Fiscal year 1960	2,500,000

The work scheduled for fiscal year 1960 involves a continuing effort on fuel element development and manufacture process development, heat transfer studies and experimentation. The bulk of the funds this year are required for irradiation services. An amendment to the original contract was made in fiscal year

1959 to provide for development of a nuclear instead of a conventionally fired superheater.

Carolina-Virginia nuclear power group:

Fiscal year 1958	0
Fiscal year 1959	$1,182,000
Fiscal year 1960	2,600,000

Funds required during fiscal year 1960 will allow for continuation of fuel element development, in-pile experiments, component development, plant system development and critical experiments. This contract, executed in fiscal year 1959, provides for AEC preconstruction research and development assistance up to a ceiling of $10,145,000 and postconstruction research and development assistance of $3,760,000.

East central and Florida west coast nuclear power groups:

Fiscal year 1958	0
Fiscal year 1959	$500,000
Fiscal year 1960	2,165,000

Work scheduled for fiscal year 1960 under this cooperative arrangement will include development of pressure tubes and fuel elements. The contract, executed in fiscal year 1959, calls for AEC preconstruction research and development assistance up to a ceiling of $8,646,000 and postconstruction assistance of $3 million.

Boiling-water prototype reactor:

Fiscal year 1958	0
Fiscal year 1959	0
Fiscal year 1960	$850,000

It is estimated that $850,000 will be costed in fiscal year 1960 to provide research and development assistance in connection with the proposed construction of a prototype reactor which may be of a boiling-water type in the size range from 50 to 100 MWE. It is anticipated that the total estimated cost of such assistance will approximate $3 million. In the event satisfactory proposals for construction of this reactor on a cooperative basis is not received by the Commission, the Commission may elect to proceed with the design, construction, and operation of the prototype at its own expense.

Intermediate size prototype reactor:

Fiscal year 1958	0
Fiscal year 1959	0
Fiscal year 1960	$1,350,000

It is estimated that $1,350,000 will be costed in fiscal year 1960 to provide research and development assistance in connection with the construction of an intermediate size prototype reactor. It is anticipated that the total estimated cost of such assistance will approximate $8 million. In the event satisfactory proposals for construction of this reactor on a cooperative basis is not received by the Commission, the Commission may elect to proceed with the design, construction and operation of the prototype at its own expense.

Unsolicited proposals:

Fiscal year 1958	0
Fiscal year 1959	0
Fiscal year 1960	$1,500,000

It is estimated that $1,500,000 will be costed in fiscal year 1960 to provide research and development assistance in support of unsolicited proposals from the utility industry to construct nuclear powerplants where the Commission determines that such nuclear powerplants will make significant contributions toward the achievement of the Commission's goals and objectives.

Philadelphia Electric Co.:

Fiscal year 1958	0
Fiscal year 1959	0
Fiscal year 1960	$3,100,000

The proposal, which was accepted by the Commission in February 1959, provides for AEC financial research and development work up to $14,500,000, plus waiver of fuel use charges of $2,500,000. Funds required for fiscal year 1960 provide for research and development on fuel materials and components, plus conceptual design studies.

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Power reactor demonstration program—Fiscal year 1958 authorization

Specifications	1st invitation			2d invitation			3d invitation			Other arrangement, Philadelphia Electric
	Yankee Atomic Electric Co.	Consumers Public Power District	Power Reactor Development Co.	Rural Cooperative Power Association	Chugach Electric Association	City of Piqua	Northern States Power Co.	East Central and Florida West Coast Nuclear Power groups	Carolina-Virginia Nuclear Power Association	
Location	Rowe, Mass.	Hallam, Nebr.	Monroe, Mich.	Elk River, Minn.	Anchorage, Alaska.	Piqua, Ohio.	Sioux Falls, S. Dak.	Not announced.	Parr Shoals, S.C.	York County, Pa.
Type of reactor	Pressure water.	Sodium graphite.	Fast breeder.	Boiling water.	Sodium cooled.	Organic moderator.	Boiling water.	Gas cooled D_2O moderator.	Pressure D_2O.	Gas-cooled graphite moderator.
Heat output	482,000 kw.	245,000 kw.	300,000 kw.	73,000 kw.[1]	40,000 kw.	45,500 kw.	203,000 kw.[2]	156,000 kw.	60,500 kw.	92,000 kw.
Electrical output, net	110,000 kw.	75,000 kw.	94,000 kw.	20,000 kw.	10,000 kw.	10,500 kw.	62,000 kw.	50,000 kw.	17,000 kw.	28,500 kw.
Amount of fuel	22,800 kg.	35,200 kg.	1,930 kg.	4,219 kg. thorium.	10,000 kg.	6,250 kg.	6,605 kg.	30,000 kg.	3,410 kg.	190 kg. U–235 894 kg. thorium.
Enrichment, percent U–235	3.4	3.0	25.6	Fully.	About 2.	1.8	1.8	1.84	2.	93.
Reactor outlet temperature (° F.)	Approximately 600°.	945°	800°	531°	950°	575°	825°	1,050°	574°	1,015°.
Reactor pressure	2,000 p.s.i.	Negligible.	Negligible.	875 p.s.i.	Atmosphere.	120 p.s.i.	600 p.s.i.	500 p.s.i.	1,500 p.s.i.	300 p.s.i.
Steam conditions (p.s.i. at ° F)	540 at 475°	800 at 825°	600 at 740°	600 at 825°	850 at 850°	450 at 550°	520 at 825°	1,000 to 1,800 at 1,000°.	415 at 725°	850 at 850°.
Criticality	July 1960.	November 1961.	August 1960.	January 1961.	May 1962.	September 1961.	May 1962.	December 1963.	June 1962.	December 1963.

[1] Includes 14,800 kilowatts of conventional superheating capacity.

[2] Includes 39,000 kilowatts from superheater.

Summary of authorization and funding for cooperative arrangements, fiscal year 1958–60 cooperative power reactor demonstration program (CPRDP)

	Total authorization		Funding (in thousands)			
	Previous estimate	Revised estimate	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960	After fiscal year 1960
A. Fiscal year 1958, CPRDP:						
1st round:						
Consumers:						
Preconstruction R. & D.	$18,165	$18,165	$2,464	$6,000	$4,268	$5,433
Unusual maintenance and fuel cycle costs	8,000	8,000	8,000	0	0	0
Construction	24,013	24,013	6,500	15,749	0	1,764
Total, consumers	50,178	50,178	16,964	21,749	4,268	7,197
Fast breeder R. & D.[1]	2,750	3,600	695	600	600	1,705
Total, 1st round	52,928	53,778	17,659	22,349	4,868	8,902
2d round:						
Elk River:						
Preconstruction R. & D.	0	0	0	0	0	0
Construction	9,269	9,397	9,269	128	0	0
Post construction	2,176	2,176	2,176	0	0	0
Total, Elk River	11,445	11,573	11,445	128	0	0
Piqua:						
Preconstruction	3,500	3,500	200	2,850	337	113
Construction	5,487	7,332	0	7,332	0	0
Post construction	3,318	3,318	0	3,318	0	0
Total, Piqua	12,305	14,150	200	13,500	337	113
Chugach:						
Preconstruction [2]	8,155	8,155	2,300	0	0	5,855
Construction	9,229	9,229	0	0	0	9,229
Post construction [2]	2,500	2,500	0	0	0	2,500
Total, Chugach	19,884	19,884	2,300	0	0	17,584
Total, 2d round	43,634	45,607	13,945	13,628	337	17,697
3d round:						
Northern States:						
Preconstruction R. & D.	5,500	7,500	5,500	2,000	0	0
Postconstruction R. & D.	500	1,000	500	500	0	0
Total, Northern States	6,000	8,500	6,000	2,500	0	0
Carolinas-Virginia:						
Preconstruction R. & D.	10,145	10,145	0	10,145	0	0
Postconstruction R. & D.	3,760	3,760	0	3,760	0	0
Total, Carolinas-Virginia	13,905	13,905	0	13,905	0	0
East central nuclear group—Florida west coast:						
Preconstruction R. & D.	8,646	8,646	0	6,097	2,549	0
Postconstruction R. & D.	3,000	3,000	0	3,000	0	0
Total, ECNG–FWCNG	11,646	11,646	0	9,097	2,549	0
Total, 3d round	31,551	34,051	6,000	25,502	2,549	0
Pennsylvania Power & Light:						
Preconstruction R. & D. (phase I)	7,000	0	0	0	0	0
Preconstruction R. & D. (phase II)	0	0	0	0	0	0
Postconstruction R. & D. (phase II)	0	0	0	0	0	0
Total, Pennsylvania Power & Light	7,000	0	0	0	0	0
Additional proposals	20,000	0	0	0	0	0
Balance not applied	0	1,677	0	841	0	836
Subtotal:						
Operating	107,115	85,142	21,835	39,111	7,754	16,442
Construction	47,998	49,971	15,769	23,209	0	10,993
Total, fiscal year 1958 program	155,113	135,113	37,604	62,320	7,754	27,435

ee footnotes at end of table, p. 210.

Summary of authorization and funding for cooperative arrangements, fiscal year 1958–60 cooperative power reactor development program (CPRDP)—Continued

	Total authorization		Funding (in thousands)			
	Previous estimate	Revised estimate	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960	After fiscal year 1960
B. Fiscal year 1960, CPRDP:						
Boiling water, R. & D.	0	$3,000	0	0	$3,000	0
Intermediate size reactors, R. & D.	0	8,000	0	0	8,000	0
Unsolicited proposals, R. & D.	0	5,000	0	0	5,000	0
Philadelphia-Electric:						
Preconstruction, R. & D.	0	12,500	0	0	12,500	0
Postconstruction R. & D.	0	2,000	0	0	2,000	0
Total, Philadelphia-Electric	0	14,500	0	0	14,500	0
Small prototype reactor, construction	0	10,000	0	0	10,000	0
Intermediate reactor, construction	0	15,000	0	0	15,000	0
Subtotal, operating	0	30,500	0	0	30,500	0
Subtotal, construction		25,000	0	0	25,000	0
Total, fiscal year 1960 program		55,500	0	0	55,500	0

[1] Total estimated AEC R. & D. cost: $4,450,000; obligations prior to fiscal year 1958: $141,000.
[2] Total estimated AEC cost: $12,380,000; obligations prior to fiscal year 1958: $1,725,000.

2. Design and engineering studies, $5,000,000

design and engineering studies will involve work on such items as nuclear superheat, heavy water power reactor, prototype reactor for nuclear tankers, reactor for remote military installations, and others. It is estimated that fiscal year 1960 costs will be $5 million.

3. Euratom program, $5,000,000

The research and development portion of the joint U.S.-Euratom cooperative program is aimed primarily at the improvement in performance of the power reactors to be constructed under the joint program and at lowering fuel cycle costs. The incorporation of such an activity in the joint program has been based on experience within the U.S. atomic energy program which has demonstrated repeatedly that major gains can be achieved in improving the performance and in lowering the operating costs of large reactors if an associated research and development program is established. It is believed that such a program will lead to substantial improvements in power levels, and savings in the fuel cycle with a resultant lowering in unit power costs. A vigorous research and development program also is expected to provide further important assurance to the industries involved that costs will decrease with time and experience and, so as gradually to diminish the necessity for the U.S. Atomic Energy Commission to provide fuel element guarantees as contemplated by section 4 of the Euratom Cooperation Act of 1958.

In formulating the research and development program, the representatives of the United States agreed that it should be established at a level that experience had indicated was desirable in this country and for a long enough period to assure that results will be obtained. Under the terms of the agreement for cooperation between the United States and Euratom, which was signed at Brussels on November 8, 1958, and which came into effect on February 18, 1959, the program is to be established for a 10-year period. During the first 5 years the financial contribution of the community and the United States is estimated to amount to about $50 million each. These 5 years will be mostly in the preoperational period since the reactors are expected to come into operation in 1963.

In addition to the amounts authorized by Congress pursuant to section 3 of the Euratom Cooperation Act Public Law 85–846 ($3 million) for the joint research, and development program, an additional $7 million is authorized for fiscal year 1960. Of these amounts it is estimated that $5 million will be costed in fiscal year 1960.

4. Reactor systems research and development, $17,700,000

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
(*a*) Reactor design and evaluation	$2,797,113	$3,400,000	$3,450,000
(*b*) Reactor physics	3,298,860	4,075,000	4,420,000
(*c*) Reactor fuels and materials development	6,136,909	5,800,000	6,550,000
(*d*) Reactor engineering	606,227	625,000	950,000
(*e*) Advanced testing and research reactors	479,590	850,000	2,330,000
(*f*) Manuals and data books	115,719	50,000	0
Total reactor systems research and development	13,434,418	14,800,000	17,700,000

The objectives of this program are to develop and evaluate those types of engineering data which are necessary either to broaden the horizons of reactor technology or, more immediately, to provide support to reactor projects now underway or in the offing. A healthy, long-range reactor development program demands that new ideas, materials, components, and processes be vigorously investigated; that advanced reactor designs be conceived and evaluated; that available nuclear engineering data be analyzed. Fiscal year 1960 costs under this program are a reflection of the continued scientific and engineering effort required to further these objectives. It is estimated that $1 million of the costs shown under this category will result from contracts entered into through the International Atomic Energy Agency for research work in the peaceful uses of atomic energy which are of programmatic interest to the AEC. This will enable the AEC to draw upon a wealth of scientific and technical competence which is not being brought fully to bear on the peaceful uses of atomic energy. Results of the projects undertaken would be made available through the IAEA to all member states.

(*a*) Reactor design and evaluation:

Fiscal year 1958	$2,797,113
Fiscal year 1959	3,400,000
Fiscal year 1960	3,450,000

This activity provides for the performance of limited theoretical and experimental work required to "prove" the value of new and promising reactor concepts. These concepts will be explored and problem areas isolated. A concerted development effort in the key problem areas will then be undertaken. If this development indicates that a concept is technically feasible and has potentialities for production of economic power, it may be recommended as the basis for a reactor project.

Investigations are currently being performed on direct conversion of fission energy (heat) to electrical energy, fast oxide breeder reactors, and a molten plutonium breeder reactor concept. The fiscal year 1960 cost estimate provides for continued effort at the fiscal year 1959 level on the molten plutonium concept, the thermoelectric conversion development, and miscellaneous design and evaluation work at Oak Ridge National Laboratory.

(*b*) Reactor physics:

Fiscal year 1958	$3,298,860
Fiscal year 1959	4,075,000
Fiscal year 1960	4,420,000

Physics studies will be continued on various possible combinations of fuels, moderators, coolants, shielding materials, control methods, reflectors, and other constituents which can be used in nuclear reactors. Cross section and other nuclear data will continue to be obtained through the use of exponential experiments, critical assemblies, and reactivity measuring facilities at various contractor sites. Beginning in fiscal year 1959, data will be obtained from a pulse neutron source (linear electron accelerator) at General Atomics, and beginning in fiscal year 1960, from an AEC-owned machine at Rennselaer Polytechnic Institute. Data obtained from all these sources will be analyzed for their significance to reactor design.

Nuclear constants and other data relating to the physics of reactors will be compiled and published. Alternate methods of reactor control will be evaluated on an expanded basis in conjunction with intensified materials investigations.

This activity also provides for the continued study of the effects of radiation on the various constituents of nuclear reactors, including such effects as changes in physical properties, corrosion and changes in reactivity and poison content.

The estimate for fiscal year 1960 represents a reasonable pricing out of the effort required to further advance our knowledge of reactor physics through accomplishment of specific projects and investigatory programs. To a large extent, this estimate is predicated upon maintaining the fiscal year 1959 level of effort at most locations.

(*c*) Reactor fuels and materials development:

Fiscal year 1958	$6,136,909
Fiscal year 1959	5,800,000
Fiscal year 1960	6,550,000

This activity provides for the acquisition of data on the physical and mechanical properties of metals, alloys, and materials which have or may have value when used in reactors. The utilization of plutonium and U^{233} as fuels will be investigated intensively. Fuels able to operate in reactors for long periods at high temperatures will be sought. Studies will be undertaken on little known materials, such as rare earth metals, which possess attractive qualities for use in reactor environments. New alloys and materials will be developed and studied. Fundamental properties of reactor materials will be determined in cases where they are inadequately known. A comprehensive program was initiated late in fiscal year 1958 to provide scientific information and technology on control rod materials. The program is being conducted by the General Electric Co. at Vallecitos, Calif., and will provide data required by reactor designers.

The development of methods for nondestructive testing of fuel elements and reactor components will be continued in order to reduce fuel element cost.

Although the specific projects to be conducted in fiscal year 1960, in most cases, will differ in detail from those conducted in fiscal year 1958 and fiscal year 1959, the estimates for fiscal year 1960 will reflect essentially the same level of developmental effort as in prior years. The increase in costs in fiscal year 1960 over fiscal year 1959 is almost wholly due to the extension (phase 2) of the control rod development program being conducted by General Electric Co. at Vallecitos, Calif.

(*d*) Reactor engineering:

Fiscal year 1958	$606,227
Fiscal year 1959	625,000
Fiscal year 1960	950,000

Included under the activity are engineering research programs aimed at the development of instrumentation and controls, and the identification of common problems in reactor heat transfer systems including, also, the investigation of heat transfer systems required for new reactor concepts.

With respect to the development of instrumentation and controls, emphasis will be given to those required in the following applications:

(1) Startup, operation, and shutdown of reactors.

(2) Processing of radioactive fuel elements and residue.

(3) New reactor systems involving extreme environmental conditions, such as high temperature and pressure, corrosive atmosphere, and high radiation flux.

Increased costs shown for fiscal year 1960 reflect a general increase in emphasis on programs being conducted at Argonne National Laboratory, Brookhaven National Laboratory, Oak Ridge National Laboratory, and Columbia University. Work at Columbia University on boiling heat transfer will be expanded. Necessary work on liquid metal and high temperature gas heat transfer will be initiated at Brookhaven National Laboratory. Work to be performed at Oak Ridge National Laboratory is aimed at (1) the modernization of reactor control systems on an across-the-board basis by utilizing new developments, such as chopper stabilized amplifiers and novel radiation detectors and (2) the investigation of basic heat transfer coefficients under extreme conditions and the characteristics of fluid flow in reactor cores. The Argonne National Laboratory will initiate a new program to develop more effective reactor instrumentation so that it will be available without the necessity for crash programs for specific reactor projects.

Funding requirements for a variety of small and special engineering studies being conducted by private concerns and universities will remain relatively constant in fiscal year 1960.

(e) Advanced testing and research reactors:

fiscal year 1958	$479,590
fiscal year 1959	850,000
fiscal year 1960	2,330,000

Included here are studies of AEC needs for additional and improved research and test reactors, conceptual design of such reactors, research, and development in support of new concepts related to specific needs, and detailed design studies.

In fiscal year 1959 conceptual design has been continued on the advanced engineering test reactor (AETR) for testing materials and fuel elements under high-flux conditions (1.5×10^{15} neutrons/cm^2 = sec), and started on a test reactor loop utilizing the design concepts already developed by Los Alamos Scientific Laboratory. This work will be correlated with the Bureau of Mines work on a coal gasification system.

The fiscal year 1960 estimate provides for (1) the detailed conceptual design and mockup of the AETR, (2) the design and assembly of a 3 megawatt test reactor loop directed toward the solution of the primary problems of a 2,500° F. process heat system (Turret), (3) the initiation at ORNL of conceptual design of novel reactors for research and test purposes, such as a reactor design for transuranic element production, (4) the initiation of a program at BNL to analyze the future requirements for research reactors from the standpoint of the research scientist, (5) beginning of conceptual design of a fast neutron test reactor (FTR) and (6) continued support of the joint AEC-Bureau of Mines development effort on process heat reactors.

The increased costs shown for fiscal year 1960 are primarily the result of the anticipated progression of the AETR and Turret programs beyond conceptual design. A minor portion of the increased costs can be attributed to the work at ORNL and to the initiation of conceptual design on the FTR.

(f) Manuals and data books:

Fiscal year 1958	$115.719
Fiscal year 1959	50,000
Fiscal year 1960	0

The presently envisaged program for manuals and data books was essentially completed in fiscal year 1958. The costs estimated for fiscal year 1959 provide for the completion of work at Argonne National Laboratory and Atomics International. No costs under this activity are anticipated for fiscal year 1960 but additional manuals and data books may be required in the future.

5. Fuel cycle development, $13 million

The objectives of the fuel cycle development program are to lower the cost of nuclear-generated electrical power by lowering fuel cycle costs. Research and development effort will be performed on all important features of the total fuel cycle: materials, operating temperatures, burnup, fabrication, and reprocessing. It includes the development, design, fabrication, and irradiation testing of prototype fuel elements and the subsequent fabrication and testing of statistically significant quantities of these elements in full scale power reactors which are scheduled to be in operation after fiscal year 1960.

Development of fuel materials will be directed primarily toward materials of special significance to a class of reactors which have developed into firm projects with the objective of accelerating the development of fuel which will lead to higher performance and/or lower cost fuel elements for these reactors. Effort will also be aimed at the development of new fuel element designs which would result in improved performance when used in full scale reactors now under construction or firmly planned. The initial work will result in the development of prototype fuel elements which could subsequently be produced in large numbers for test in full scale power reactors.

The objective of the fuel cycle development program is to reduce both the capital cost and fuel cost of nuclear power. Improvements in the fuel cycle can lead to higher power densities, thus lower capital costs and cheaper fabrication and/or longer life, thus lower fuel costs.

6. Reactor safety, $9,700,000

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
(*a*) In-pile systems development	$4,979,855	$2,960,000	$6,607,000
(*b*) Out-of-pile development	1,433,413	2,540,000	3,093,000
Total reactor safety	6,413,268	5,500,000	9,700,000

The objective of the reactor safety experimental and theoretical program is to develop an understanding of reactor hazards in order either to eliminate these hazards or to control them by safe and economical means. The constant goal is to provide information directly usable by reactor engineers assuring a safely designed reactor system.

(*a*) In-pile systems development:

Fiscal year 1958	$4,979,855
Fiscal year 1959	2,960,000
Fiscal year 1960	6,607,000

A potential reactor hazard that is not fully understood is the excursion or runaway behavior of nuclear systems. Work in this vital area deals with the kinetic behavior of reactors starting with small excursions and going up to dangerous instabilities. Experiments of this type will continue with the SPERT reactors (special power excursion reactor test) at NRTS and the KEWB reactor (kinetic experiment on water boilers) at Santa Susanna. Information will continue to be provided from Spert I. The first quantitative data should be obtained from the Spert III high pressure and Spert II medium pressure reactors—criticality in fiscal year 1959 and fiscal year 1960, respectively. Fabrication will be initiated on a new unpressurized reactor, Spert IV, required for investigations of hydrodynamic, oscillatory, and other kinetic behavior not possible in the other Spert reactors, but important to the pool reactor concept. A new core geometry will be studied in the KEWB reactor. Theoretical programs will accompany the experimental reactor kinetic programs. Analytical work on the kinetics of reactor types other than homogeneous will be inaugurated. Safety studies on homogeneous fast reactors of the Lampre type will be undertaken by the Los Alamos Scientific Laboratory.

Increased costs in fiscal year 1960 reflect the provision of heavy water for Spert II, fabrication of Spert IV, and increased operating costs resulting from the full-time use of the three Spert facilities.

(*b*) Out-of-pile development:

Fiscal year 1958	$1,433,413
Fiscal year 1959	2,540,000
Fiscal year 1960	3,093,000

Investigations will continue on the large and dangerous energy releases that might occur if molten reactor fuel were to contact the water coolant within a reactor core. The energy released by such an event could be great enough to rupture the core vessel and the outer containment shell. Experimentation will be expanded in the vital area of fission product release from molten or burning reactor fuel. Deposition and identification of these fission products within the reactor housing will be studied along with methods of fission product cleanup. Reactor containment (core vessel and outer shell) will be studied extensively. Emphasis will be placed on the response to dynamic loads which will be experimentally developed to simulate possible destructive energy releases. Experiments with the spontaneous ignition of reactor metals will proceed.

7. Separations Systems Development, $6,000,000

	Actual fiscal year 1958	Estimate fiscal year 1959	Estimate fiscal year 1960
(*a*) Aqueous chemical processing development	$2,563,235	$2,400,000	$2,940,000
(*b*) Volatility processing development	1,298,655	1,000,000	1,440,000
(*c*) Closed cycle processing development	3,612,717	1,800,000	1,620,000
Total separations systems development	7,474,607	5,200,000	6,000,000

Separations systems development programs are directed toward obtaining design criteria on chemical systems for the reprocessing of irradiated reactor fuels. Current estimates indicate that a significant portion of nuclear power costs will be incurred for this function. At present, no proved technology exists which offers acceptable economy and which can be applied to the heavy volume of spent fuel loads forecast for civilian power and military reactors. During fiscal year 1960, development efforts will be pointed toward pilot-plant proof of promising chemical systems.

(*a*) Aqueous chemical processing development:

Fiscal year 1958	$2,563,235
Fiscal year 1959	2,400,000
Fiscal year 1960	2,940,000

Major goals are to develop and prove the mechanism for fuel dissolution, to develop improved extraction process methods and data, and to continue development of reprocessing chemistry applicable to multicomponent fuel compositions.

Developments of the Zircex and Darex processes for treating zirconium and stainless steel fuels will be continued on both laboratory and engineering scales to determine reaction rates, product losses, heat dissipation, behavior of fission products and plutonium, and to find optimum materials of construction. General laboratory studies will be continued on alternative aqueous processes. Work on fuel handling and mechanical processing systems will be continued.

Data will be obtained on dissolution rates of various fuels in multicomponent dissolution systems. Corrosion behavior of such systems built of several materials of construction is to be evaluated.

The increase shown for fiscal year 1960 is related to (1) mockup of fluidized bed preparation of plutonium compounds at Argonne National Laboratory in an attempt to develop a cheaper plutonium fuel cycle, and (2) increased responsibilities at ICPP for new fuel types, including advanced ANP types, and fuels containing boron and silicon.

(*b*) Volatility processing development:

Fiscal year 1958	$1,298,655
Fiscal year 1959	1,000,000
Fiscal year 1960	1,440,000

General development of the volatility technology approach, which involves use of sodium fluoride absorption beds for recovery of uranium hexafluoride, will be continued. Additional operational testing of the fused salt volatility pilot plant at Oak Ridge will be conducted using fused salt feed which contains a higher level of radioactivity than that experienced in processing the aircraft reactor experiment (ARE) fuel. The pilot plant will then be modified to permit processing of short-cooled fused-salt fuels and, subsequently, of solid fuel elements. Laboratory development and design work will be conducted to supplement this program.

General development will be continued also on another aspect of volatility technology in which uranium is fluorinated to the volatile UF^6 and purified by fractional distillation. Emphasis will be placed on the development of technology for the recovery of plutonium by volatility processes, and on the development of corrosion resistant construction materials.

At both Argonne and Oak Ridge National Laboratories, fiscal year 1959 represents a reorientation year for volatility development in which emphasis is changing from demonstration of overall feasibility to adaptation of the techniques to individual fuel types. At both laboratories, actual plant operation will be deemphasized in favor of redesign, modification of existing plants and fabrication of new equipment. Increased costs in fiscal year 1960 are associated with more extensive pilot plant operations.

(*c*) Closed cycle processing development:

Fiscal year 1958	$3,612,717
Fiscal year 1959	1,800,000
Fiscal year 1960	1,620,000

This program is in actuality broader in scope than just chemical processing or pyrometallurgical processing alone, since it involves reprocessing through decontamination, reenrichment, and refabrication, performed in a facility closely integrated with a reactor. This approach contrasts with most other fuel cycle development work which is based on the major assumption that manual han-

dling will be required at some point during the fuel cycle and that high fission product decontamination is therefore essential.

The closed cycle program will include scaled-up development of technology applicable to advanced EBR-II-type cores as well as to other future applications. A major goal is to devise and laboratory-test new flowsheets for special alloy and ceramic fuels.

Major goals in the work being performed by Atomics International are development of technology applicable to future sodium reactor experiment uranium dioxide (ceramic) type fuels, and the continuation of engineering development on methods of closed cycle processing of thorium-uranium fuels.

Work will be continued in the development programs at Iowa State College, Carnegie Institute of Technology, and the National Bureau of Standards, which are aimed at basic development of closed cycle technology. The decreasing costs shown for this activity reflect the phasing out of major mock-up work at Atomics International. The program is essentially in a stage of transition and reorientation. Increased activity is anticipated in the future.

8. Radioactive residues management, $4,500,000

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
(*a*) Treatment development	$1,044,568	$1,200,000	$1,350,000
(*b*) Systems development	1,930,930	2,000,000	3,150,000
Total	2,975,498	3,200,000	4,500,000

Treatment and systems development programs are directed toward obtaining design data and other information for the segregation and management of radioactive byproducts of operations relating to the development and use of reactors.

(*a*) Treatment development:

Fiscal year 1958	$1,044,568
Fiscal year 1959	1,200,000
Fiscal year 1960	1,350,000

Major immediate goals of work performed under this activity are to provide supplementary design data for the aluminum nitrate calcination process, to provide scale-up data and further design information for an initial waste solids storage facility, and to complete the calcination and waste storage process studies. The primary effort in waste calcination studies is in support of the Idaho chemical processing plant program. Major goals are to determine, through operation of the ANL hot pilot facility, the course of fission products in the calcination process and to adapt this process to types of radioactive wastes other than aluminum nitrates.

Longer range goals include expanded studies aimed at separation of fission products from bulk solids (Al, Zr, stainless steel, process chemicals, etc.) to achieve high decontamination factors (10^6 or greater). The goal is to recover uncontaminated fuel from irradiated fuel elements and to separate and concentrate fission products for industrial use or safe economic storage.

The increase shown for fiscal year 1959 and fiscal year 1960 represents effort in support of the ICPP waste calcination program at both Phillips Petroleum Co. and Argonne National Laboratory.

(*b*) Systems development:

Fiscal year 1958	$1,930,930
Fiscal year 1959	2,000,000
Fiscal year 1960	3,150,000

Three basic situations underlie the current systems development program: (*a*) Development work has indicated that there are feasible methods for ultimate disposal of highly radioactive wastes, but no proven solution has been reached; (*b*) as the atomic energy industry expands, problems of environmental

control are becoming more widespread. Consequently, the need for quantitative environmental data and information on systems for controlling the release of radioactivity is becoming more acute; (c) to meet the needs of the expanding industry, the time has come when laboratory scale work on treatment and management of high level fission product residues must be advanced to pilot plant and field scale experiments.

In fiscal year 1960, in high activity systems, transitions to pilot plant and field scale investigations will be required in order to evaluate engineering and environmental feasibility. Supporting laboratory development work will have to be continued. In low level waste dispersal and environmental control, new areas will be brought under study to keep pace with requirements. Full-scale field investigations and model work, where practicable, will be undertaken. Air cleaning research and development work will continue.

9. Merchant ship reactors, $5,990,000

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
(a) Pressurized water reactors	$299,157	$1,633,000	$3,200,000
(b) Maritime gas-cooled reactor	596,506	2,300,000	1,490,000
(c) Maritime boiling-water reactor	0	400,000	750,000
(d) Health, safety and operating rules and regulations	110,791	350,000	250,000
(e) Advanced systems development	539,408	117,000	300,000
Total merchant ship reactors	1,545,862	4,800,000	5,990,000

The objective of the nuclear merchant ship program is to develop economically competitive nuclear-powered merchant ships which will operate safely in unrestricted world commerce. To achieve this objective, a cooperative development program has been established with the Maritime Administration, Department of Commerce, aimed at orderly sequential development of technically proven reactor concepts in promising ship applications. A longer range phase of the program, also underway, is the study and development of more advanced nuclear propulsive systems and optimum ship designs. To assure the entry of nuclear-powered merchant ships into normal channels of foreign and domestic commerce with maximum safety and economy, and minimum operating restrictions consistent with good practice, a complementary support program has been started. In carrying out the overall program, the technical, funding, and contractual responsibilities of the Atomic Energy Commission apply to the nuclear propulsion system; the Maritime Administration has a similar role for the ship and its impact on world maritime operations.

In summary, program developments to date are:

The NS *Savannah*, which is the first nuclear merchant ship, is being constructed on schedule, with ship completion and reactor startup timed for early calendar year 1960. All major contracts have been awarded; the difficult initial ship design was completed in 7 months, instead of the more usual 12 to 15 months; the keel was laid in May 1958; detailed design of both propulsion plant and ship are on schedule; criticality of the critical experiment was achieved; and material procurement and hardware fabrication are well underway.

Detailed work on the boiling water reactor concept has confirmed preliminary analyses that, with further development, nuclear propulsion can achieve economic operation in specific ship applications. Planning, design, and development work is also going forward on the gas-cooled reactor-gas turbine combination which is a most promising ship application.

Work has begun on auxiliary projects necessary to assure the safe operation of nuclear-powered merchant ships and their acceptance in world commerce. These include establishing ship operating procedures and emergency safety measures; and analyzing the hazards involved in nuclear ship operation.

(a) Pressurized water reactors:

Fiscal year 1958	$299,157
Fiscal year 1959	1,633,000
Fiscal year 1960	3,200,000

Cost detail is as follows:

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Research and development	$299,157	$1,633,000	$2,000,000
Fuel fabrication	0	0	1,000,000
Test operations	0	0	200,000

Under Public Law 848, the 84th Congress authorized the design, construction, and operation of a nuclear-powered passenger-cargo vessel, the NS *Savannah*. The ship will have a 20,000 shaft horsepower (74 mw. thermal) nuclear propulsion plant and will carry about 60 passenges and 9,400 tons of cargo. Babcock & Wilcox, under project authorization, is designing and fabricating the propulsion plant; New York Shipbuilding Corp. will install the reactor, and perform related AEC work, as well as construct the ship for the Maritime Administration.

Requests for operating funds tie closely to the "short" construction schedule for the project and have three objectives: first, to provide technical review and support for the project, including the construction of a loop for the irradiation work; second, to develop and fabricate cores to meet the *Savannah*'s operating requirements; third, to develop and test operate improved, more economic and reliable plants components for general application to subsequent merchant ships.

Key project dates

1. Start power core fabrication: January 1959.
2. Deliver reactor pressure vessel to shipyard: April 1959.
3. Ship launching: July 1959.
4. Deliver fuel elements to shipyard: December 1959.
5. Reactor startup, test, and trials: January–May 1960.
6. Experimental and demonstration period: Through fiscal year 1963.

ORNL is providing backup assistance in the form of reactor physics, metallurgy, and related test services until the completion of the construction project in fiscal year 1960. This assistance is particularly necessary due to the short time schedule for the project. A water loop, designed to provide in-pile testing of elements of the second and subsequent cores for the NS *Savannah*, is being fabricated, and will be completed in fiscal year 1959.

The Atomic Energy Commission has the responsibility for providing all components required by the nuclear propulsion plant, including reactor cores, until the reactor system has been test operated to the satisfaction of the Commission and the Maritime Administration. This test period is expected to require 2 to 3 years operation. The core provided by Babcock & Wilcox under the fixed-price construction contract, will go critical for the first time in the ship. General Electric Co. is performing research and development work on an improved standby core, leading to delivery in the third quarter of fiscal year 1960. This will provide a spare core at startup to insure continued operability of the ship. A core research and development program is also underway to develop more economic core designs.

In line with the President's directive for use of the NS *Savannah* as a "floating laboratory," an important program scheduled for starting in fiscal year 1960, is the development, installation, and test of improved nuclear plant components. Scheduled for early investigation are those items which materially affect the economics of nuclear ship operation, such as coolant pumps, control rod drive mechanism, and instrumentation. The objective of this work is to provide reliable, improved, simplified components for general nuclear merchant ship use, as well as to provide specific improvements in the NS *Savannah*.

The current schedule for the project calls for start of trials and test operations late in fiscal year 1960. The cost estimate for fiscal year 1960 provides for test, trials, experimental operation, and maintenance of the NS *Savannah*'s nuclear propulsion plant and the performance of engineering work.

(*b*) Maritime gas-cooled reactor:

Fiscal year 1958	$596,506
Fiscal year 1959	2,300,000
Fiscal year 1960	1,490,000

Design feasibility studies indicate that a high temperature gas-cooled reactor with a closed-cycle gas turbine offers great promise for the eventual production of low-cost propulsive power. It has the added potential advantage of compactness and relatively light weight.

In fiscal year 1958, a joint AEC-Maritime developmental program was undertaken leading toward the construction of a prototype nuclear propulsion system suitable for shipboard installation in a merchant ship of the 20,000 shaft horsepower class. Under this arrangement the AEC has funding responsibility for the reactor and related components; the Maritime Administration is funding for the development of the gas turbine and associated machinery. Work on both portions of the system is being carried out under an AEC-administered contract with General Atomic of General Dynamics Corp. The work is being carried out on a four-phase basis as follows: Phase I, research and development; phase II, engineering development and preliminary design of the prototype plant and facilities; phase III, detailed design and construction of the prototype plant and facilities; and phase IV, test operation.

The AEC funded work centers around the development of a reactor system in the 50 to 70 mw. (thermal) range with a reactor gas outlet temperature of 1,300° to 1,400° F. Through fiscal year 1960 work will be confined to phase I and will stress development of fuel materials, core design, working fluids, and plant control, and will lead to a reference design of the plant. In order to test fuel and materials related to this program under operating conditions, a gas-cooled test loop is being installed in a Hanford pile.

The AEC program during this period involves a steady conservative research effort to insure the solution of critical problems before proceeding to subsequent stages. The information obtained from this work will provide important data for central station power applications in this temperature range.

	Actual fiscal year 1958	Estimate fiscal year 1959	Estimate fiscal year 1960
Hanford gas-cooled test loop	$343,668	$650,000	$90,000
Phase I: Research and development:			
Development of conceptual design	200,000	250,000	0
Development of fuel material and reactor core	52,838	780,000	1,000,000
Development of overall plant control system	0	190,000	120,000
Development of reactor pressure vessel and internals	0	80,000	50,000
Development and fabrication of critical experiment	0	310,000	180,000
Other: Fuel reloading, biological shielding, emergency coolant	0	40,000	50,000
Total, maritime gas-cooled reactor	596,506	2,300,000	1,490,000

(*c*) Maritime Boiling Water Reactor:

Fiscal year 1958	0
Fiscal year 1959	$400,000
Fiscal year 1960	750,000

Economic analyses and technical work to date indicate that a boiling water reactor system installed in a large tanker is the maritime application of nuclear power which can most closely approach economic competitiveness at an early date, and that this application also has excellent long-range possibilities. Major advantages of the tanker application are (*a*) weight reductions can be fully converted to cargo capacity; (*b*) cargo can be used for shielding; (*c*) long trade routes and short turnarounds result in more effective use of a nuclear power plant. The special advantage of the direct cycle boiling water reactor for marine application are (*a*) lower capital cost and weight as compared to pressurized water reactor; (*b*) high efficiency; (*c*) safety and simplicity of operation.

The initial objectives of work in this program are to solve engineering problems associated with the utilization of the boiling water reactor in a merchant ship, and to engineer the system to a point where design and construction can be undertaken. As in the case of the NS *Savannah*, a land-based prototype is not required since the concept has been technically proved in experimental boiling water reactor and other installations.

It is planned that development work will start in fiscal year 1959 and continue in fiscal year 1960 with special emphasis on solving the engineering problems associated with pitch and roll on free surface, reactor control, and the effect on design of the power demand of merchant ship operation.

Cost details are as follows:

	Actual fiscal year 1958	Estimate fiscal year 1959	Estimate fiscal year 1960
Design engineering	0	$200,000	$100,000
Core development	0	200,000	550,000
Component development	0	0	100,000
Total maritime boiling water reactor	0	400,000	750,000

(*d*) Health, safety, and operating rules and regulations:

Fiscal year 1958	$110,791
Fiscal year 1959	350,000
Fiscal year 1960	250,000

The success of a program to introduce nuclear-powered merchant ships into normal channels of world commerce is dependent upon gaining acceptance by others. This, in turn, is dependent upon the ability to assess and minimize potential environmental hazards resulting from nuclear ship operation, and to make adequate safety provisions. The objective is to minimize accidents and their effects, to achieve public confidence, and to prevent costly restrictions in ship operation. The Maritime Administration is responsible for obtaining data relative to marine environmental conditions as they affect safe ship operation; AEC is responsible for evaluating this data as well as for obtaining necessary data associated with the reactor system.

(1) *Environmental safety.*—A field survey was started in fiscal year 1958, to continue into fiscal year 1960, to develop tide, current, and salinity information as a basis for an analysis of the transport of fission products in harbors and estuarial waters. The Coast and Geodetic Survey is conducting the survey and the Chesapeake Bay Institute of Johns Hopkins University will analyze the data, correlating it with data obtained from model surveys, and formulating means for more generalized application. Chesapeake Bay Institute will also analyze survey data obtained from other harbor model studies.

(2) *Reactor safety—shipboard safety.*—Armour Research Foundation is analyzing and developing countermeasures and materials to be employed to minimize hazards from accidental release of radioactive contamination from ships.

Studies will be made in fiscal year 1960 leading to the design of contamination features which will protect passengers and crews in the event of such an emergency, and an analysis will be made of the requirements for radiation monitoring equipment.

(3) *Analysis and design of shore facilities.*—AEC is determining requirements for the maintenance, repair, and refueling of nuclear-powered merchant ships. Maritime Administration will design and construct shoreside facilities to meet these requirements.

(4) *Movie—documentary film.*—In order to facilitate acceptance of nuclear ships by the general public and regulatory groups in this country and abroad, it is planned to prepare technical films based on the tests and trials and experimental operations of the *Savannah*. This film footage, together with that made during the construction of the vessel, will be an important part of the technical and public information program associated with the experimental operation of the *Savannah*.

Cost detail is as follows:

	Actual fiscal year 1958	Estimate fiscal year 1959	Estimate fiscal year 1960
(1) Environment safety	$61,617	$95,000	$50,000
(2) Reactor safety—shipboard safety	23,287	60,000	100,000
(3) Analysis and design of shore facilities	25,887	195,000	50,000
(4) Movie—documentary film	0	0	50,000
Total health, safety, and operating rules and regulations	110,791	350,000	250,000

(c) Advanced systems development:

Fiscal year 1958	$539,408
Fiscal year 1959	117,000
Fiscal year 1960	300,000

The objective of this work is to analyze nuclear systems which promise lower costs and improved operating characteristics for the long-range benefit of the American merchant marine. It involves feasibility and optimization studies of promising advanced nuclear systems for marine use and preliminary engineering development of systems planned for early utilization in merchant ships.

(1) *Feasibility studies.*—In fiscal year 1958 feasibility studies were made on marine applications of the boiling water, gas-cooled, organic moderated, and water reactor systems, involving supercritical steam. The results demonstrated great promise for early economic utilization of the boiling water reactor and a long-range potential utilization of the gas-cooled system. Additional work may prove desirable on the organic and advanced pressurized water systems for specific project applications. Work will be carried out in fiscal year 1959 and 1960 to explore reactor systems suitable for large vessels of 100,000 SHP or greater and to smaller vessels of 5 to 10,000 SHP. Studies will also be carried forward on propulsion systems for vessels of an advanced design, and exploratory studies of unique commercial applications of nuclear power at sea will be undertaken.

(2) *Engineering development.*—The purpose of this work is to provide sufficient preliminary engineering and developmental work to bring promising reactor systems to a point where systems for a specific ship can be designed in detail at some future time. Problems associated with marine applications include pitch and roll, the weight and size of the system, shielding, reactor control, safety features, etc.

Cost detail of this program is as follows:

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
(1) Feasibility studies	$539,408	$117,000	$125,000
(2) Engineering development	0	0	175,000
Total, advanced systems development	539,408	117,000	300,000

10. Army power reactors, $11,000,000

The objective of the Army power reactors program is the development of a family of reactor systems to fulfill military requirements for nuclear powerplants for use in remote areas and for uniquely military purposes. To meet this objective all reactor concepts which show promise of fulfilling military requirements must be studied and evaluated. Four general reactor concepts are under development into military reactor systems: (1) pressurized water reactors; (2) boiling water reactors; (3) gas-cooled reactors; and (4) fast reactor systems.

Army power reactors	Actual fiscal year 1958	Estimate fiscal year 1959	Estimate fiscal year 1960
(a) Army package power reactors	$551,179	$1,602,000	$1,400,000
(b) Argonne low power reactor	444,623	651,000	600,000
(c) Gas-cooled reactor systems	4,072,586	6,200,000	6,000,000
(d) Military compact reactors	55,360	347,000	2,000,000
(e) Food irradiation reactor	800	0	0
(f) General support	0	300,000	500,000
(g) Advanced reactor studies	252,840	0	500,000
Total Army power reactors	5,377,388	9,100,000	11,000,000

(*a*) Army package power reactors:

Fiscal year 1958	$551,179
Fiscal year 1959	1,602,000
Fiscal year 1960	1,400,000

(1) Stationary medium power reactor No. 1, SM–1 (formerly APPR–1)

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Research and development	$464,283	$472,000	$350,000
Fuel fabrication	13,317	0	0
Test operation	56,618	145,000	150,000
Total	534,218	617,000	500,000

The R. & D. program continues to be directed toward improving plant reliability and reactor system component lifetimes, and extending knowledge of reactor performance characteristics. Additional research and development tasks include improvement of plant components, irradiation effect studies, development of decontamination methods, and boiling of core I with an instrumented element. Test operating costs are shared with the Department of Defense.

(2) Stationary medium powerplant No. 2, SM–2 (formerly APPR–1B)

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Total	$16,961	$785,000	$600,000
Research and development	16,961	785,000	600,000

This project is for the design and development of a core and related structures capable of operating at approximately a 28-thermal-megawatt power level for a period of 1 year. The core will be installed in a DOD plant producing a net six electric megawatt. Fiscal year 1960 efforts will include core nuclear and thermal design, pressure vessel design, metallurgical development, welded fuel element assembly development, hydraulic analysis of fuel elements, and control rod drive development. The fiscal year 1960 program carries to completion the project which was initiated in late fiscal year 1958 at the Department of Defense request for the design and development of a higher output core to be used in an APPR type plant to be constructed by the DOD. A core of this type will be fabricated in fiscal year 1961.

(3) Portable medium powerplant No. 1, PM–1 (formerly APPR–2)

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Total	$0	$150,000	$200,000
Research and development	0	150,000	0
Fuel fabrication	0	0	200,000

The major efforts in fiscal year 1960 in the development of this air transportable nuclear powerplant will be directed toward core fabrication. The objective of this project is the development of a "factory prepackaged" plant constructed in modules, thereby enabling rapid field erection and relocation. Construction of this plant for service testing at an Air Force installation will be initiated in fiscal year 1959. Under the joint funding agreement, AEC will fund for the reactor and related facilities and Air Force will fund for the conventional plant. Emphasis will be placed on packaging, reliability, and quality of power output. Fuel fabrication will be initiated in fiscal year 1960.

(4) *Nuclear test plant*

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Total	$0	$50,000	$100,000
Research and development	0	50,000	100,000

During fiscal year 1959 a conceptual design study for the nuclear test plant (NTP) was instituted. This study will be completed in fiscal year 1960. In addition, development of test and operating instrumentation required to quickly sense and accurately record NTP system conditions, parameters, and changes will be undertaken.

(*b*) Argonne low-power reactor (SL–1):

Fiscal year 1958	$444,623
Fiscal year 1959	651,000
Fiscal year 1960	600,000

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Research and development	$335,797	$370,000	$250,000
Fuel fabrication	100,691	16,000	0
Test operations	8,135	265,000	350,000

In fiscal year 1960 the primary effort in the SL–1 prototype operation will be directed toward determining operating costs, plant capabilities, reliability, and to what extent unmanned operation is feasible. The major research and development effort will be directed toward correcting problems discovered during operation, simplifyng the plant, improving packageability, and improving the efficiency and simplicity of the fuel elements. The SL–1 became critical in the first quarter of fiscal year 1959 and full power will be reached late in calendar year 1958. Fiscal year 1960 costs represent first full year of operation.

(*c*) Gas-cooled reactor systems:

Fiscal year 1958	$4,072,586
Fiscal year 1959	6,200,000
Fiscal year 1960	6,000,000

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Research and development	$3,032,786	$2,960,000	$4,110,000
Fuel fabrication	44,030	540,000	950,000
Test operations	0	0	890,000
Experiment fabrication	995,770	2,700,000	50,000

Gas-Cooled Reactor Experiment (GCRE) development was undertaken to obtain experience and operating data from which reactors suitable for use in portable, closed-cycle, nuclear-electric powerplants could be designed and built. The GCRE will be operating as intended, during fiscal year 1960 to provide information concerning reactor physics, fuel element and control system performance, heat transfer and gas-flow calculations, and materials corrosion. A second core loading will be required by the end of the year and development will continue to insure that this loading, when fabricated, will be substantially improved over the first.

A Department of Defense requirement now exists for development of a prototype powerplant. This requirement will be met, in part, through the use of a reactor heat source similar to that in GCRE. GCRE experience will be of immediate value therefore, as prototype development progresses.

Inpile experiments will continue in support of fuel element development. Coordinated with GCRE operations and the prototype delivery schedule will be

dynamic tests of promising fuel element designs in gas-cooled loops at the Battelle research reactor and at the engineering test reactor. Based upon the results available, fabrication of the first core loading for the prototype will be initiated late in the fiscal year. Development will also continue in the general areas of improving control technique, shielding, and mechanical design.

When the GCRE can be diverted from testing for prototype development, testing of a full core of solid moderated fuel elements will be planned. To this end, solid-moderator core materials studies will continue and fabrication of the core will be initiated in fiscal year 1960. Portable power reactors with such fuel elements could offer higher thermal efficiencies, temperatures, and power output, simplified control, and lower unit cost.

(*d*) Military compact reactors:

Fiscal year 1958	$55,360
Fiscal year 1959	347,000
Fiscal year 1960	2,000,000

In fiscal year 1960 the principal effort will be directed toward the design and development of the compact reactor system selected from the studies completed in fiscal year 1959.

Additional information of a classified nature is presented on classified pages 111.

(*e*) Food irradiation reactor:

Fiscal year 1958	$800
Fiscal year 1959	0
Fiscal year 1960	0

The reactor approach for providing a gamma source for food irradiation was abandoned in fiscal year 1958 at the request of the Department of Defense in favor of a cobalt source.

(*f*) General support:

Fiscal year 1958	0
Fiscal year 1959	$300,000
Fiscal year 1960	500,000

Funds in this activity are required to cover the cost of (1) operation of the hot cells and shop and maintenance building to be constructed during fiscal year 1959 and fiscal year 1960 at the Army Reactor Experimental Area, (2) overhead and services provided by the National Reactor Testing Station operator, and (3) general research and development support of the Army program by the Oak Ridge National Laboratory. There follows an itemization of the estimates:

	Estimate fiscal year 1959	Estimate fiscal year 1960
AREA operations	0	$100,000
NRTS charges	$100,000	200,000
ORNL support	200,000	200,000

(*g*) Advanced reactor studies:

Fiscal Year 1958	$252,840
Fiscal year 1959	0
Fiscal Year 1960	500,000

These studies include the continuous evaluation of advanced reactor concepts to determine adaptability of results to package reactor systems for foreseeable long-range requirements.

11. Naval propulsion reactors, $90,000,000

The naval reactors program is aimed at developing a group of pressurized water nuclear propulsion plants suitable for installation in ships ranging from small submarines to large combatant surface ships. The naval program in fiscal year 1960 continues at a slightly increased level with emphasis on the development

of reactor cores of improved design and longer life; the test operation and evaluation of naval prototype reactor plants; and the operation of special development test facilities. Development of a natural circulation pressurized water reactor plant will be underway.

12. Airplane propulsion reactors, $68,700,000

The airplane propulsion reactors program is directed toward the development, fabrication, and testing of nuclear reactors and associated components, and their integration into aircraft nuclear propulsion systems. The development of turbomachinery and other Air Force oriented components of the propulsion system is being performed under Department of the Air Force contracts.

The fiscal year 1960 estimates provide for the continuation of the program at essentially the fiscal year 1959 level, and cover the research and development program, the fabrication and operation of reactor experiments, and the operation of the ground test facilities at the National Reactor Testing Station.

13. Missile propulsion reactors, $27,900,000

The objective of the missile propulsion reactors program is to demonstrate the feasibility of nuclear reactors for application to ramjet and rocket propulsion systems.

The fiscal year 1960 program will continue the research and development effort, and provide for fabrication leading to the operation of additional experimental reactors at the Nevada test site.

14. Satellite power sources, $12,100,000

This program is directed toward the development, fabrication, and testing of small, light-weight package-type auxiliary power systems utilizing nuclear derived heat radioisotopes and compact reactors. The SNAP III program to develop small inexpensive proof-of-principle nuclear powered devices with unique conversion techniques will continue. The initial unit in ths program, a 5-watt model producing electric power by means of thermoelectric converters, was demonstrated in fiscal 1959.

15. Operational services, $1,300,000

Included in this category are the nondistributed costs of the materials testing reactor, and engineering test reactor, and the operation of the National Reactor Testing Station, that portion of the chemical processing plant at Idaho related to the reactor development program and such other costs as startup and standby, and transportation and security shipments.

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
(a) Operation of test reactors	$2,634,154	$1,200,000	0
(b) Chemical processing plant	295,652	200,000	$700,000
(c) Operation of national reactor testing station	168,508	280,000	380,000
(d) Startup and standby costs	2,655,035	1,500,000	0
(e) Transportation and security shipments	162,122	200,000	220,000
Total	5,915,471	3,380,000	1,300,000

(*a*) Operation of test reactors:

Fiscal year 1958	$2,634,154
Fiscal year 1959	1,200,000
Fiscal year 1960	0

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Materials testing reactor:			
Gross cost of operation	$4,298,868	$4,700,000	$4,800,000
Less irradiation services to other programs	4,298,868	4,700,000	4,800,000
Net cost	0	0	0
Engineering test reactor:			
Gross cost of operation	2,707,972	4,300,000	5,400,000
Less irradiation services to other programs	73,818	3,100,000	5,400,000
Net cost	2,634,154	1,200,000	0

The materials testing reactor and the engineering test reactor operate to provide high flux for research purposes for various AEC contractors, AEC-sponsored and public groups in the study of radiation damage; to assist with fundamental research on transuranic and other elements; to aid in the development of fuel elements for various types of reactors; to produce isotopes; and to provide a source of neutrons for cross-section measurement work. The cost of these services is charged to users of the services, and there are, therefore, no costs shown here. In fiscal year 1958, most of the ETR costs were not distributed to the using programs since experimenters were preparing their experiments for insertion into the ETR. In fiscal year 1959, the ETR will not be fully utilized for the whole year and for this reason all costs will not be distributed to the users. In fiscal year 1960, it is expected that costs will be entirely distributed.

(*b*) Chemical processing plant:

Fiscal year 1958	$295,652
Fiscal year 1959	200,000
Fiscal year 1960	700,000

This is a continuing activity and provides for the routine operation of the chemical processing plant at the National Reactor Testing Station at Idaho to recover enriched uranium from irradiated fuel elements related to the reactor development program. The increased costs in fiscal years 1959 and 1960 are based on programed reprocessing of MTR–ETR and STR fuels.

(*c*) peration of National Reactor Testing Station:

Fiscal year 1958	$168,508
Fiscal year 1959	280,000
Fiscal year 1960	380,000

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Gross cost of operation	$5,149,895	$5,380,000	$6,280,000
Less distribution credits	4,981,387	5,100,000	5,900,000
Net cost	168,508	280,000	380,000

This activity is for operating and maintaining the national reactor testing station. The costs are distributed to the programs using the services of the station. The increase in operating costs is for related communications and transportation costs.

(*d*) Startup and standby costs:

Fiscal year 1958	$2,655,035
Fiscal year 1959	1,500,000
Fiscal year 1960	0

This category provides for the startup and standby of certain special reactor materials production facilities and related termination costs. Fiscal year 1958 costs were for termination of the contracts associated with the production of yttrium and partial termination of beryllium contracts. Fiscal year 1959 costs are for deactivation and dismantling of the Luckey plant and for related costs associated with beryllium contracts. No funds are required for fiscal year 1960.

(*e*) Transportation and security shipments:

Fiscal year 1958	$162,122
Fiscal year 1959	200,000
Fiscal year 1960	220,000

This estimate is for coordinating, escorting, and providing armed protection for shipments of highly classified materials and documents, as well as materials that cannot be transported by common carrier because of health and safety hazards.

16. Equipment not included in construction, $19,815,000

Equipment requirements for the reactor development program are estimated at $19,815,000 for fiscal year 1960. This requirement is to support the continuing program for development of civilian and military reactors. Approximately two-thirds of the amount requested is required for the military reactor programs, and the balance is for the civilian power rector program. There follows a breakdown of the equipment requirements estimated for each major installation in relation to its other operating costs.

	Other operating costs	Equipment costs
Argonne National Laboratory	$28,434,000	$1,500,000
North American Aviation	26,913,000	3,300,000
Phillips Petroleum Co.	17,130,000	800,000
Pratt & Whitney	17,500,000	1,000,000
General Electric, Lockland	44,700,000	3,500,000
Bettis plant	65,000,000	3,800,000
Knolls Atomic Power Laboratory	36,420,000	1,500,000
Los Alamos Scientific Laboratory	19,070,000	1,300,000
Oak Ridge National Laboratory	25,055,000	780,000
All other	107,363,000	2,335,000
Total costs	387,585,000	19,815,000

The classified information referred to in the preceding table is contained in classified book I.

INCREASED POWER AT SHIPPINGPORT

Mr. McCONE. Mr. Chairman, there have been a number of areas that have been very encouraging that have occurred in the last year indicating very clearly to us progress in the direction of more economical nuclear power. I think the two most significant developments are, first, the one which Admiral Rickover has just spoken of, the increased power of the Shippingport plant.

It was a plant originally conceived as developing 60,000 kilowatts and now it is being raised to 150,000 kilowatts with sufficient indication that it will go higher. We are suggesting that the power company install generating capacity of 175,000 kilowatts.

Now, this is with no addition to the reactor physically. It is the addition of some pumping equipment and water circulating equipment and control equipment, but it is accomplished by the installation of a new improved design of core, and it tells you that science has delivered to us the means of obtaining greater efficiency and more heat out of a given quantity of uranium fuel.

BOILING WATER REACTORS

A second development at the Argonne Laboratory is for a different type of reactor, the boiling water reactor—and you know the Shippingport is pressurized water—the Argonne reactor known as the experimental boiling water reactor was completed 2 or 3 years ago, designed for 20,000 megawatts of thermal capacity. It has been progressively increased in output by improvement of one sort or another. We are now installing a new core and making some changes and prior to the end of this calendar year, prior to December, we think that that plant will operate at 100,000 or five times the original criteria.

Carrying that a little further, the Dresden plant which will be completed and put on steam starting in mid-September of this year, is designed to produce 180,000 kilowatts of electrical. The engineers are now quite convinced that there is a very greater capacity in that reactor.

The new plants that are being designed at the present time reflect the higher power density of the reactor and for that reason I was able to report as I did the day before that our most recent studies indicate a very substantial decrease in the cost of power. So we feel that the trends are in the right direction, and we are very much encouraged.

PRODUCTION OF POWER IN PAST YEAR

Mr. CANNON. Summing up the year, Mr. Chairman, how many kilowatts of power in the aggregate have been added?

Mr. MCCONE. There is a total number now of reactors of all types in operation or under contract and under construction that are either now operating or will be within the next 2 years—2½ years—having just over a million kilowatts, 1.28 million.

Mr. CANNON. Of course, what we are really interested in, Mr. Chairman, is the progress of industrial power. We would like to know how many kilowatts of marketable industrial power have gone on the line.

Mr. MCCONE. In the last year?

Mr. CANNON. Yes; in the last year, and what excess is that over the total of the previous year.

Mr. MCCONE. I don't think there have been any plants completed and put on line——

Mr. CANNON. You are not producing any more kilowatts of commercial power this year than you produced during the last year?

Mr. MCCONE. In the last 12 months; no, sir.

Mr. CANNON. That would not indicate any progress at all. What we are looking for are practical results. To that extent, we have been at a standstill.

Mr. MCCONE. No, you have not been at a standstill, sir. Because there are a number of projects that have been under construction. One, the Dresden plant, now nearing completion, will be completed in September of this year. This is the biggest plant incidentally.

Mr. CANNON. So far as the production of marketable commercial power is concerned, we have not produced a single extra kilowatt over the previous year.

Mr. MCCONE. That is correct.

DIFFERENCE BETWEEN 1959 APPROPRIATION AND CURRENT ESTIMATES OF COSTS FOR REACTOR DEVELOPMENT PROGRAM

Mr. CANNON. Let me ask you this: The amount appropriated for 1959, the fiscal year 1959, was something over $400 million. But you are now estimating that you will use only $342 million in 1959.

Now, somewhere along here you overestimated. What occasioned that overestimate or what caused that underrun of your last year's estimate?

Mr. MCCONE. Mr. McCarthy, do you have the figures on that?

Mr. MCCARTHY. Mr. Chairman, the difference is about $73 million; in the amounts that were appropriated last year, there were $39 million for the Sherwood program which now appears under our physical research program. The underrun in the program, in the reactor program, amounted to $34 million during the year. This runs through all of the various activities under the reactor program.

I could enumerate them here. In our civilian power program we underran in our own program about $12 million. There were some $2 million or $3 million in the cooperative program. The Navy program ran under by about $5 million and the airplane propulsion underran by about $2.7 million. There are others. It comes to a total of about $34 million that we underran in the program throughout the year.

There are a number of factors in these——

Mr. CANNON. According to the figures you have here, in 1959 you had an underrun of $58 million. You requested over $400 million and your estimate now is only $342 million. So that is something in excess of $58 million, either in underrun or an overestimate.

Mr. MCCARTHY. Well, it was an underrun in the various programs. In the civilian programs, a number of the items, was the fact fact that the fuel element fabrication did not take place as rapidly as we anticipated. This, of course, will be caught up in 1960.

Mr. CANNON. That makes not only an underrun for this year, Mr. Chairman, but this is the second consecutive year. You have had 2 consecutive years in which you have had an underrun by substantial amounts. What assurance can you give the committee that your 1960 estimate is not likewise inflated, that you are not again asking for more money than will be required for the program; and in view of the experience of the last 2 years, how much money could we subtract from the amount requested in order to more nearly apportion the amount actually needed?

Mr. MCCONE. Mr. Chairman, in making up the figures that we submitted to you for 1960, you recognize that the underruns of 1958 and 1959 were due very largely to programs slippages. And therefore, we have in our budget reviews very carefully analyzed the precise progress of the several projects under the program to assure ourselves as accurately as we could that the construction progress and engineering progress was realistic and would proceed as planned.

If it does proceed as planned—and we satisfied ourselves that it would and where we were in doubt we made adjustment, then this money will be needed.

FLUID FUEL REACTORS

Mr. CANNON. You tell us on page 55 that you expect to discontinue the fluid fuel reactors, that you will not pursue the fluid fuel reactor program beyond 1959 as an approach to economical nuclear power.

But at the same time you ask for $7.5 million for the program in 1960. Now, if you expect to discontinue the program, if you do not expect to pursue it beyond 1959, why ask for $7.5 million for 1960?

Dr. PITTMAN. Mr. Chairman, could I answer that question, sir?

Mr. CANNON. Dr. Pittman.

Dr. PITTMAN. I think there is a slight misunderstanding with one regard, sir. We do not intend to completely discontinue the fluid fuel system. We intend to shift the objective of the fluid fuel system from an objective of early competitive nuclear power to an objective of breeding in the thermal breeding system.

Apparently, the only way in which we are able to use thorium as a fuel is for the thorium to make U^{233} which is a fissionable material, and the best way to use it is through a breeder system. We have looked at the three fluid fuel systems, the aqueous homogeneous, the molten salt, and the liquid metal system, and we have reached the preliminary conclusion on the basis of the information that we have at this time that the aqueous homogeneous system offers the greatest possibility for thermal breeding.

We do, therefore, sir, propose to continue operation and to continue looking and doing development work in the fluid fuel system. We think it will be primarily in the aqueous homogeneous system.

We are, therefore proposing if this developmental work proves our current thinking to be right, to rapidly decrease the work in the molten salt and the liquid metal, but to continue in the aqueous systems.

Mr. CANNON. Judging solely by your report and by your request, this is one of those areas to which Admiral Rickover referred just now and in which we are spending money for research programs that possibly could be discontinued temporarily. Why could we not concentrate on those things that are immediately essential and leave this for future development?

Dr. PITTMAN. Sir, I think we are concentrating on those things which can offer the most immediate opportunity of achievement of economic nuclear power.

Actually, we are looking at three basic types of reactors. We are looking at what we might call the lower temperature reactors, that is the water reactors, the organic reactors, in water we have heavy water as well as light water.

We are looking at high temperature reactors, the reason for the high temperature reactor system is that in order to get efficient utilization of the temperature you want to get this temperature as high as possible.

In addition to those two systems, both of which—and incidentally, in the high temperature, we are looking at both gas cooled and liquid metal cooled in order to get the higher temperatures you can't get out of the water system. You are limited by the fact that the coolant is water and you can't go above a certain temperature and pressure.

In addition to those two which offer an opportunity of early competitive power and the generation that I was speaking about, Mr. Evins, we would certainly love to have competitive power in high cost areas in 5 years and that is our objective.

In addition to that, however, sir, we have to look to the somewhat longer range future at the time when we want to use all of the natural resource of thorium and uranium and in order to do this, the only possible way we can do it is to use the breeding system.

When you consider that in uranium that is mined, only a small fraction of that uranium is U^{235}, which is fissionable, the utilization of the remainder of it depends on a system of breeding the U^{236} into plutonium which is fissionable and looking over the other raw materials, thorium, of breeding U^{233} in the thorium.

So when we are looking at the breeder systems—and that includes the fast breeder work we are doing, and it includes the fluid fuel work at a much decreased rate next year because we are recognizing it is a longer range program—that is the third general system of reactors we would like to look at.

I feel it is very important that we do look at this time a little bit further than just the systems that will give us economic power in the immediate future.

Mr. CANNON. Well, it is hard to escape the conclusion that you are scattering your fire here already and that it would better serve your purposes, as Admiral Rickover indicated, to concentrate on the immediate problems which promise earlier results and basic progress. You are in a better position this year than you were last year to pick out the one or two reactor concepts which hold the best promise for economical power production.

You are now in a position to pick out one or two and follow them to the end and really get results.

Mr. MCCONE. That, sir, is what we have been attempting to do. As Dr. Pittman has indicated we have set aside this particular area of breeders as one area for continuing research. We have narrowed that down so that we are concentrating on one rather than three processes.

In that regard we are following exactly the concept that Admiral Rickover mentioned. I think that we would be very wrong to abandon research in this advanced concept although it does not give us a prospect of power producing unit within a year or two; it is something that is several years off. But when we do get it, it is going to replace everything else because the very concept in which it returns more fissionable material to you than you feed in gives you what appears to be possibly a negative fuel cost.

So this is something that must be pursued and cannot be looked upon as an alternate to or just one more reactor concept of the several that we are developing of a lower temperature that are not breeders and for immediate prospect of reasonably economic power.

EXPERIMENT FABRICATION

Mr. CANNON. You are adding a new factor here. Your proposition here is for experiment fabrication in the Government program. Just what is that experiment fabrication?

Dr. PITTMAN. Sir, as we look at new ideas, not necessarily new concepts and new reactors, but different ideas within reactor concept in the basic groups that we are talking about, we have often reached a point where further work in the laboratory even though the critical experiment is not productive and we must reach a point sometime

where we assemble the critical mass and find out what are the facts that exist in this reactor concept.

This can generally be done in what we, for lack of a better term, can call a quick and dirty procedure and relatively cheap procedure of assembling the materials without any effort to get power out of them. It is purely a procedure to prove the nuclear physics of the particular set of conditions we want to try.

We have for the first time put in here an amount of money to do that. An example of the type of thing we are talking about, in the gas-cooled system, one of the concepts that we have been looking at for time on paper and in the laboratory is the use of pebble—they call it a pebble-bed reactor. It is the use of fuel in the form of balls with the gas coolant bubbling up essentially through those graphite fuel balls.

We would try in this case a small reactor experiment in the very cheap manner, say out at Idaho Falls that would give us the information about the stability characteristics of this type of unit. We would then be able to tear it down and decide whether to go on with a true reactor unit.

It is the quickest, cheapest way of getting the real information as to whether a reactor concept is worthy of spending more money in the development of the final structure of it so to speak.

Then, we have several ideas along this line. There is very serious consideration, just as an example, to cooling with molten sulfurate and molten salt.

ORGANIC MODERATOR REACTOR

Mr. CANNON. Now, your organic moderator reactor. The committee is rather impressed with that. What could you do to push that along a little more rapidly?

Dr. PITTMAN. The organic moderated reactor last year—we operated the OMRE. It was a quick and dirty experiment. We have operated this. We have proven out the feasibility of the use of organic material as a coolant, the fact that the radiation of organic does not decompose to the point where it can no longer be used. We are fully cognizant of the potential advantages of the organic material. Therefore, we have in the 1960 program, taking into account what is already underway, in addition to the continued operation of this experiment at Idaho Falls, we will be constructing this organic moderated and cooled reactor at Piqua, Ohio.

If this budget is approved, we are proposing to design and start construction in 1960 of a flexible experimental organic cooled reactor at Idaho Falls.

All we have done to date in the organic system is to prove one particular organic material is able to act as a coolant and moderator. We would like to prove out that we can use other organic materials that are better than at present.

One of the worst problems in the organic system is the fact that organic materials in general, are poor heat transfer materials. The way to improve this is either to get an organic material that is a better heat transfer material, to put something in the organic that will improve its heat transfer heat characteristics or boil the organic just as we boil water in the boiling water reactor.

Mr. CANNON. Why can't we get along with that?

Dr. PITTMAN. We are increasing our request for the organic research and development in that area. We feel it is an extremely important area of operation. It is one of the low temperature operations that I mentioned, plus the reactor development.

Mr. CANNON. Why go abroad in all these new fields when you have something good here at home? Why not stay with this until you develop it?

As I said before, why scatter our fire? The thing Admiral Rickover emphasized was that we should emphasize what we most immediately need and first get results in that one field.

Why go afield in all these other matters when we have something here that seems to promise basic results?

REQUIREMENT FOR HIGH TEMPERATURE STEAM

Dr. PITTMAN. Sir, I think we will put the maximum effort we can on the organic. I would like to give you an example of why we should look at something other than low temperature. The steam conditions that we are able to get out of a boiling water reactor, pressurized water, or even organic, are much poorer than the steam conditions that are currently used in the modern up-to-date electrical generating plant.

It seems to us that while we are pushing these reactors we should also be looking for other systems that will give us better steam conditions so that we can get more efficient generation of electrical current.

Certainly we have to strive for the time when we can use the most modern, up-to-date generating equipment on the market. This is not possible at this time with a boiling water or pressurized water or organic reactor.

It is possible by adding fossile super-heat to the basic nuclear reactor, to get steam conditions up. This is being done in some of the commercial plants and some of the plants we are building, but we want to strive to get away from that.

One of the things I might add that we are doing in this field so that we can make the boiling water reactors and the water reactors capable of producing better steam conditions, is that we are seriously looking into a developmental way at using nuclear heat to super-heat this steam.

I don't think we are scattering our shots too broadly, sir. I think we have to get higher temperatures.

DETROIT-EDISON FAST BREEDER PLANT

Mr. CANNON. What progress are you making on your Detroit-Edison fast breeder?

Dr. PITTMAN. The Detroit-Edison fast breeder plant being built by the Detroit-Edison Co. and its group of affiliates, is proceeding either on or ahead of schedule as far as construction is concerned. It is planned to go critical, if I remember the date, next September. That is September of 1960, which is on schedule. That is a fast reactor. It does not use the moderator that we discussed the other day. It does use fast neutrons. It will certainly be a major milestone in the nuclear energy program in this country when it is constructed.

EXPERIMENTAL BREEDER REACTOR, NO. 2

Now, in that same system we have under construction, as you know, at Idaho Falls, the EBR–II, experimental breeder reactor No. 2, which is a complete complex. It is the reactor and it is the fuel recycling system.

In order for a breeder reactor to really work, you have to do more than really breed. You have to breed the plutonium in this case and you have to breed it in large enough quantities so that there is what we call a short doubling time. You do not want to have one reactor holding its own only.

The experimental breeder reactor will be the first integrated complex that we have built that will have the reactor, its chemical processing plants, its fuel recycling plants, so that we can take the product of the reactor, purify it and put it back in the reactor. It is only through these studies in this particular system that we will find out how much of the material that is actually bred in the reactor we can efficiently get back into the reactor or into some other reactor if there were another one there.

So that program is going on. That accounts for the fact that we are raising the cost of our fast breeder work in 1960. This, of course, will be of extreme value to the longer-range program.

Mr. CANNON. I am apprehensive about that. You have licensed that Detroit-Edison plant.

Mr. MCCONE. That is right.

Mr. CANNON. Is that proceeding safely?

Mr. MCCONE. Yes, sir.

Mr. CANNON. Any danger, you think, has been adjusted?

Mr. MCCONE. Yes. The Commission investigated that thoroughly and concluded that the license should be issued.

Mr. CANNON. Mr. Boland?

The committee will stand adjourned until 10 o'clock tomorrow morning.

FRIDAY, JUNE 26, 1959.

Mr. CANNON. The committee will resume its hearings on the Atomic Energy Commission's estimates.

COOPERATIVE PROPOSALS

There are actually firm commitments for proceeding into construction on all the cooperative proposals for which you are applying for funds in 1960, Mr. Chairman?

Mr. MCCONE. Yes, there are firm commitments on the program. In not every instance is every detail of the contract negotiated, but negotiations are quite well advanced.

Mr. CANNON. On all of them?

Mr. MCCONE. On all of them; yes.

DESIGN AND ENGINEERING STUDIES

Mr. CANNON. How does your design and engineering studies item relate to the advance designs study item in last year's bill?

Mr. MCCONE. The advance design study item of last year related essentially to three major projects, the boiling water, the pressurized

water and the organic cooled reactors which were large reactors. In addition, there was a study of a superheat reactor, a small reactor, which was partially completed, and, as I reported, will be completed in November.

The item for advanced design studies proposed this year does not cover those same areas because those specific projects were authorized and that work is carried forward.

Perhaps Dr. Pittman would like to discuss the details of this particular item.

Mr. CANNON. What we were particularly interested in, Mr. Chairman, was the heavy water and the nuclear superheat items, along with the rest. We wonder if there was uniform emphasis on all of them and if the nuclear superheat and heavy water items are receiving sufficient attention at this time.

Mr. MCCONE. Yes, I think so. I will take those one at a time.

NUCLEAR SUPERHEAT REACTOR

With regard to the nuclear superheat reactor, the designs have not been completed. That project has not advanced to a point where we can make a final decision on the design that we wish to proceed with.

Mr. CANNON. To what is the delay due?

Mr. MCCONE. It is not a delay. It is due to the fact this is quite an advanced step. There is a very considerable amount of research and engineering work. It is proceeding under the direction of Dr. Zinn. He has made a preliminary report which is very encouraging and has advised us his final report will be completed by the end of November.

He has given us some indications as to where he thinks he is going to be at the end of November. If his studies as they mature support his forecasts, we will be able to proceed with the conception and engineering of a plan, and we will propose to do so immediately after receipt of his final analysis of the problem.

Mr. CANNON. And you expect to be in that position by the end of November?

Mr. MCCONE. By the end of November, and it will take several months following that to do the conceptional engineering, the preliminary plant layouts, the estimates of construction, and so forth, and at that time we will be able to come to the committee for an appropriation for the construction of the plant itself.

Mr. CANNON. In the meantime, and in the future, the studies on these two items will receive equal consideration with all the rest?

Mr. MCCONE. Yes; indeed they will. I feel that the future, as I said the other day, of the boiling water and the pressurized water reactors rests in the successful solution of our superheat problem for the reason that the steam that comes from the water reactors is of relatively low temperature compared with the steam that comes from a conventionally fired boiler, and therefore the efficiency of the turbo-generator is comparatively low.

If we can by superheat increase the characteristics of the steam, then we improve the overall efficiency of the plant.

Mr. CANNON. I would be glad if you would give us a breakdown of your design and engineering studies, with the amount allocated as to each study.

(The requested information follows:)

Statement of U.S. Atomic Energy Commission—Items of proposed work and approximate cost levels included in category, "Design, and engineering studies," $5,000,000, fiscal year 1960

	Millions
Design and engineering studies	$5.0
Heavy water power reactor	2.0
Prototype reactor for nuclear tankers	1.0
Reactor for remote military installations	.5
Power reactor utilizing nuclear superheat	.5
Other programs	1.0

Mr. CANNON. As you have indicated, you will be ready to start construction immediately?

Mr. MCCONE. We will not be ready to start construction immediately.

Mr. CANNON. When will you be ready to start construction?

Mr. MCCONE. We would be ready to start construction in about a year, not before that.

There will be a period following the work Dr. Zinn is doing of conceptional engineering and estimating, crystallizing the plans for the plant itself, that must go on before the detailed designs and construction are started. It is for that reason we have not come to you for the construction funds, but will do so in the fiscal year 1961.

Mr. CANNON. And with the amounts allocated you will be able to proceed through the conceptional engineering stage?

Mr. MCCONE. That is correct.

NATURAL URANIUM HEAVY WATER REACTORS

I would like, if I could, to mention this question of natural uranium heavy water reactors. That is very much the same condition, but not quite as far advanced. We have great hope we will solve the question of a natural uranium heavy water reactor.

Mr. CANNON. Is it a more difficult problem or is it that you have not been able to give it the attention you have been able to give the other studies?

Mr. MCCONE. I think a little of both. I think it is more difficult, and I do not think in the past as much attention has been given to this question as has been given to the water reactors and so forth.

There could be persuasive arguments as to why we should have a natural uranium reactor. This would eliminate the dependence upon enriched fuel, and since this Government is the only source of enriched fuel it would free not only the domestic utility, but the utilities of foreign countries, upon the dependence of a fuel source that was in the hands of the Government. This would be very desirable. Furthermore, enriched fuel, as you know—U^{235}—competes with our weapons program. Some people fear we might have a step-up in the weapons program and therefore a withdrawal of the enriched fuel as a source of fuel for nuclear power.

These are the reasons why we are exploring with great urgency the question of a natural uranium reactor. I hasten to say our economic studies have not indicated as yet that it will produce power that will be competitive with other nuclear powerplants.

Mr. CANNON. Your studies up to this time do not exclude this method, the possibility of producing on a basis comparable with your other studies?

Mr. MCCONE. They do not exclude it, no. I think, however, it is more intuition and judgment, together with the studies and indications that have resulted from the work of the Canadians, that leads us to a point of optimism, than it is the results of the engineering studies that we have made to date.

Mr. CANNON. Mr. Chairman, a year is a long time. It is a longer period of time now than it was 20 years ago. The world is moving at such a rapid rate in every way in every department of science and industry that the committee is inclined to think a year is a very, very long time. Do you not think that could be shortened? I am speaking of these two particular studies.

Mr. MCCONE. The best advice I can get is that with respect to the natural uranium reactor it cannot be shortened. With respect to the superheat reactor there is hope on the part of the engineers that can be shortened.

Drawing on my own experience and recognizing the problems they face, I am not willing to share that hope that it can be shortened, because I can see there are problems that have to be answered, technical, and then the answer must be checked, and these tests take time. I cannot tell you, Mr. Chairman, that this time could be shortened, although I agree with you that a year is a long time.

SUPERHEAT REACTOR

Mr. CANNON. In view of the importance, Mr. Chairman, of exploring every possibility, would it not be wise to spend a little money in construction in order to be ready in event you found you did need it? It is of such vital importance that you better run the risk of perhaps not needing the construction than needing the construction and not having it. If we were to provide a little money here for construction, could you make such preliminary preparations as might be useful in event of the solution, or near solution, of these problems?

Mr. MCCONE. I think in these two matters it would not make any significant difference.

Mr. CANNON. Can you think of any circumstances where you could use the construction money at all?

Mr. MCCONE. No. I can tell you there have been a great many starts made that have proven to be quite wrong and quite costly.

Mr. CANNON. Of course, in every scientific study you go up blind alleys. That is the history of scientific research.

Mr. MCCONE. I would like to point out to you, sir, in this morning's paper I read with considerable interest that a heavy water natural uranium test reactor was being built in Canada as reported at twice what was estimated a short time ago. This, I think, is the price of moving into construction early.

Mr. CANNON. You think then this excessive cost was due entirely to poor planning or lack of planning?

Mr. MCCONE. I do not know, sir, in this instance. I have not had a chance to go into it. I am just commenting on a remark that appeared in this morning's New York Times.

Since a very significant part of your power cost is in the amortization of your capital investment, as you know, I think it is only prudent to do your research, development, and engineering first. I do not think it speeds up your progress to start construction prematurely.

Mr. CANNON. Of course, Mr. Chairman, we want to be guided by your judgment. I know in making your decisions you take into consideration the fact that a great deal is hanging in the balance at this time, and in view of the urgency of the situation, both domestic and international, you overlook no step which might advance progress in any of these fields.

When you come before us next year, certainly you will be able to report to us all the progress that has been made that could be made under the circumstances.

EURATOM

Now you are programing $5 million for Euratom. I would be glad if you would review briefly the Euratom cooperation act and explain what the funds will be used for.

Mr. MCCONE. Euratom is a program which, as you know, was authorized last year. The object is to assist in the construction of approximately 1 million kilowatts of nuclear powerplants in the Euratom countries, the six Western European countries. Part of the arrangement was to provide on a matching basis research and development assistance which would lead to the construction of these plants.

Last year I think a total of $3 million was authorized and this year the authorization bill carries $7 million, and the indication is there will be about $5 million of expenditures.

Last night I had a long talk with Mr. Hirsh, the President of the Euratom Council, who has been in the United States for the past 2 weeks examining our nuclear power development. He told me that he has in hand indications from six or seven utilities in the six countries, and he is quite hopeful that he will receive some interesting proposals in September and that by the first of the year he will be able to come to us seeking our approval of the construction of several plants in the European countries.

EFFECT OF FUEL AVAILABILITY IN EUROPE

I was impressed with his optimism. I hope that he is correct. I hasten to point out to you, however, that the change in the fuel availability in Europe has somewhat dampened the feeling of urgency for these plants. There is no change in the long-range outlook—the need for power and the dependence on nuclear power—but with 50 million or 60 million tons of coal piled around above ground, and with coal being shipped from the United States to Europe for $4 a ton where the rate used to be $15 a ton, there is a little different atmosphere or attitude with respect to the urgency of the problem on the part of the utilities. I hope Mr. Hirsh is right in his optimism; neverthless, these people are pretty realistic and they may not move quite as fast as they indicated they would last year.

Mr. CANNON. You expect to use all of the $5 million?

Mr. McCone. Yes, we do.

Mr. Cannon. Just how will you allocate this $5 million?

Mr. McCone. We will allocate this on a matching basis for research and development work necessary to support these projects. There are three contracts, I believe, that have now been let.

Dr. Pittman. We have let two.

Mr. McCone. We have let two.

Dr. Pittman. We evaluate all the proposals that come in and recommend they be let.

REACTORS SYSTEMS RESEARCH AND DEVELOPMENT PROGRAMS

Mr. Cannon. With all the other programs on reactor research why is it necessary to increase the catchall reactor systems research and development program?

Dr. Pittman. As you can see on page 81, Mr. Chairman, this is broken down into the various aspects of the reactor programs that are not aimed at specific projects. This is the area where we gather the basic information that is needed across the board regardless of what project we are working on. It is the area in which we develop the oxides and the carbides and the new types of fuel materials that can then be used in these specific reactors. The relatively small increase is just because of the increasing knowledge we have gotten in past years. We are able to adequately spend the money in these areas, and it is in these areas, sir, we will get the information that will really solve some of the basic problems of the future.

Mr. Cannon. In view of your experience you possibly will be able to handle this work with $16 million?

Dr. Pittman. Sir, the estimate we have presented we have reviewed a good many times and in our opinion it is the best estimate as to the amount of work that should be done to give us adequate coverage in these fields.

Mr. McCone. How much was that estimate reduced by the Commission from the amount that the division requested?

Dr. Pittman. I do not recall the figure. Perhaps Mr. McCarthy has it.

Mr. McCarthy. I do not recall that particular activity. I know that there was a reduction.

Mr. McCone. It was screened down very sharply.

Mr. Cannon. To be absolutely safe you think you could use $17 million?

Mr. McCone. That would be difficult for me to say without going into the details.

This was a figure that the committee concluded was necessary after our very exhaustive budget review. I would like to point out, Mr. Chairman, if I could—and I do this with a good deal of pride, incidentally—that in the preparation of this budget the Commission as a body sat and reviewed every single item in it. We had meeting after meeting that stretched into the late night, and this reflects the judgment, not only of the staff and the review committees that are customarily set up in the Atomic Energy Commission's staff and in the staff of other agencies, but this reflects the judgment of the Commissioners themselves.

43118—59——16

Furthermore, there were instances where there was a question of debate as to how essential something was. Various Commissioners actually went to the site, to Argonne, or Brookhaven, or elsewhere, to make an onsite examination to determine whether we could get by with a little less and whether it was actually essential.

I have been very pleased that the Bureau of the Budget, which in its role is usually critical of every department of Government, in our instance has been quite complimentary over the exactness of our review of this budget.

Mr. CANNON. As between providing too little money or providing too much money for any of these activities, we would rather, if we are going to gamble, provide too much. But in view of your record, if you can get along with a less amount than is indicated here—and I am certain that in making your estimates you have given us an outside figure—we do not want to put into the budget this year any surplus funds.

FUEL CYCLE DEVELOPMENT PROGRAM

I note a material increase here in the fuel cycle development program. You are running that from $6 million up to $13 million. You are more than doubling it. Why that rather unusual increase in this estimate?

Dr. PITTMAN. The situation on this fuel cycle development program is that now in the years in the immediate future, 1960 and 1961, more and more of the reactors that have been planned for the past 2 years will be coming into being. They will therefore be in a position of needing the fuel elements that will be burned up to give the power. It is in the area of increasing the life of the fuel and of increasing the life of the fuel and increasing the burnup that we can get the most out of the power reactors that will be coming in. The increase from $6 million to $13 million in this particular year is because of the timing of the reactors that are now coming in, or will be coming in within the next 2 years. Previously our developmental effort had to be on those aspects that were necessary to get the reactors designed and constructed. Now, the emphasis must go toward those areas in these particular reactors that are coming in that will allow us to get the most out of those reactors, and this does include the developmental programs that are absolutely necessary to cut the cost of fabrication and to give longer fuel life and greater burnup, and that is what the fuel cycle program is aimed at doing, sir.

COMMERCIAL SHIP REACTORS

Mr. CANNON. As an illustration of what we are trying to do here, and one reason why we are scrutinizing these estimates a little closely, on page 1016 of last year's hearing you estimated $700,000 for advance system development work on commercial ship reactors, but when you come in this year you now show a program of only $117,000 for 1959. Why that rather unusual drop?

Dr. PITTMAN. May I ask Mr. Eddy to answer that question?

Mr. EDDY. First, I will qualify my position here. My project is the *Savannah*, and I am filling in for the rest of the program, so I will try the best I can to give the view that my superiors would give on this.

The advance systems development considered several different reactor types. During the year we determined that the boiling water concept was most likely to be available for going into hardware to build a ship in the immediate future. Therefore, we concentrated our efforts on plans that we believed could be built in the near future, and we have dropped down the funds for monitoring other reactor types. For instance, we feel that the organic reactor at some date will be useful in a ship, so we are carrying a small amount of funds so that we can determine what things have to be done to a reactor type such as organic to make it useful for shipboard application.

We use the technology and the information developed by the other programs, the civilian power reactor programs, for most of our work. Our work is confined in this stage more to that which would adapt an existing reactor type to a ship, so the drop, I believe, reflects our selection of the boiling water type to exploit and therefore we are expending the money in the boiling water concept rather than pursuing other avenues at the same time.

Mr. CANNON. For the fiscal year 1958 you had $539,408 for the fiscal year 1959, $117,000, and for 1960, you are asking $300,000?

Mr. EDDY. The 1958 figure included the boiling water.

Mr. CANNON. I mean that last year you asked for $700,000, but are using only $117,000, and the next year $300,000. Do you wish to make a comment, Dr. Pittman?

Dr. PITTMAN. I wish to say one thing: This evaluation of advance reactors for the maritime program obviously has to take into consideration, and does take into consideration, the evaluation work that is going on in the other areas, as Mr. Eddy said.

We are not trying in this program to develop some new and exotic reactor to use, it is rather to evaluate the pressurized boiling water and organic reactors so the level will vary, depending upon the availability of information from the other programs, sir.

Mr. CANNON. Are there further questions?

Mr. MAGNUSON. I have no questions.

ADVANTAGES OF THE NATURAL URANIUM REACTOR

Mr. JENSEN. You spoke of your work in the development of the natural uranium reactor. Do you consider, Mr. Chairman, there is a possibility of advantages in the natural uranium concept which would use fuel in a less expensive manner and still get the same results as we get from other concepts? Do you and your staff and scientists believe there are great advantages to be had in your natural uranium reactor?

Mr. MCCONE. Yes, Mr. Jensen. We feel that there are great advantages in the development of a natural uranium heavy water reactor. For that reason we think that the question should be pursued energetically. The studies to date, from a purely technical point of view, have not indicated that a natural uranium heavy water reactor will be truly competitive for the reason that it requires a very large and costly facility to bring about the reaction necessary to produce the heat and consequently the power. We do not think that the potentialities have been fully exhausted, and for that reason we desire to pursue this matter and have provided in this budget a substantial amount of money for that purpose. If we are successful we contemplate asking

for authority and funds to build a reactor, or to make arrangements to have it built, to demonstrate this process. This would have unique interest quite different than any other concept because natural uranium is available from many sources. It can be purchased competitively in the market. There is no dependence upon the gaseous diffusion plant at Oak Ridge. There is no conflict with the weapons program. There is no Government monopoly involved. Foreign nations would not be concerned lest a change in attitude of this country would deprive them of fuel sources. All of these are advantages.

However, these advantages mean nothing unless the plants prove to be competitive. I cannot tell you now that they will be competitive. There is sufficient hope, however, to warrant exhausting the possibility.

Mr. JENSEN. If the possibilities which you hope to discover through research and from all of your investigations into the possibilities of this natural uranium reactor program prove to be good, then will the time be shortened from the time a plant gets under construction until the power is put on the line as against other concepts?

Mr. MCCONE. No. The plant in its physical proportions will be large; if anything, larger than an enriched plant.

Mr. JENSEN. Where will the time be saved, if any?

Mr. MCCONE. There will not be any.

Mr. JENSEN. There will be no time saved?

Mr. MCCONE. No time.

Mr. JENSEN. In a few words you explained quite fully the advantages that a natural uranium reactor might have over other plants. But you do not expect that we can produce electric power from a natural uranium reactor for less than other concepts. Do you hope someday to be able to do that?

Mr. MCCONE. The objective of the effort is to develop a natural uranium concept that will produce power as cheaply, if not more cheaply, than other types of nuclear powerplants.

Mr. JENSEN. The advantage is what, in a few words?

Mr. MCCONE. The advantages are to have power as cheap as from other nuclear sources and to have it from a natural source rather than from an enriched source of uranium.

Mr. JENSEN. How does the heavy water moderated natural uranium reactor compare with a gas-cooled natural uranium concept? Do you understand my question?

Mr. MCCONE. Yes.

Mr. JENSEN. Can you explain that in a few words or get someone to do it?

Mr. MCCONE. The feeling is that in seeking a concept for producing economic power that the characteristics of heavy water in a reactor system as a moderator are such that there is a strong probability that it will produce the desired result.

There are several coolants of which gas might be one and heavy water another. We are proceeding with a program of a gas coolant. We think this other must be explored and possibly a plant built. Would you like to add to that?

Dr. PITTMAN. No, sir. The only thing I might add is you can use either heavy water as a moderator or graphite, as the British have used. The advantage of heavy water is the heavy water absorbs less

neutrons nonproductively and you have better neutron economy and it leads to what would be considered a better reactor.

Mr. JENSEN. Our committee chairman mentioned the fact that a year was a long time, but shorter than it used to be, to wait to get these reactors on the line. I agree with him that we are all hoping that we can go forward fast under this program. But I must say that England went forward possibly just a little too fast in construction of her gas-cooled reactor to the point that there was a lot of bugs not discovered in that concept until after the power had been put on the line and the plants had been in operation for some time.

I was there. I went to Calder Hall. They had had what they called an incident or two. We would call it an accident over here, or something worse. A few days after we left they had another incident. Because of that they cooled off the other nations that had been negotiating for these reactors from England.

We want to go as fast as we can, but I know our chairman, as well as every American, wants to be sure that the bad bugs are taken out of all these reactors before they are put in operation, because we could have an accident occur which would really cause terrific damage and loss of life and property.

I think in the final analysis we will take your word for it, the word of the Atomic Energy Commission.

I believe you testified yesterday, Mr. Chairman, that there had been no additional power put on the line from atomic reactors in fiscal 1959.

Mr. MCCONE. That is correct.

INDEMNITY LEGISLATION

Mr. JENSEN. Was that partially due to the fact that it was only 2 years ago that Congress passed the bill which would make investment safer in atomic-energy reactor plants than was previously the case before passage of the bill? The bill, as you know, provided that private utilities who built these reactors were to stand the first $65 million to $100 million of the first daamge cost, and then the Government would stand $500 million for any damages which occurred through any one explosion, so to speak. Before this legislation it was not possible to get as much private utility cooperation with your Commission, with the Government, so to speak, as we had hoped for because of the fact that they could not risk the capital of their shareholders to the degree that was necessary to build one of these plants until that law was passed, and we have only had 2 years since that law was passed to get the construction we had hoped for. Is that not about the answer?

Mr. MCCONE. I think the passage of that act by the Congress was a very salutary move because it obviously afforded the utilities and industry a protection and indemnification against a hazard that hung over them in all of their plans. I do not think this alone has served to unlock the door toward private participation in these matters, but I think it has been very, very helpful. Without it progress, from a private industry standpoint, would be at a standstill because industry could not secure insurance against this hazard, which is almost incalculable, against very remote events, and therefore it was necessary to supply this indemnification.

PLANTS UNDER CONSTRUCTION

Mr. JENSEN. During fiscal 1959 and fiscal 1958 how many atomic energy reactor plants have been under construction and how many kilowatts of power will those plants generate when completed and when will those plants that have been under construction in fiscal 1958 and 1959 be completed and the power put on the line? They surely will produce a lot of power.

Mr. McCONE. There are 13 projects.

Mr. JENSEN. Just supply it for the record.

Mr. McCONE. All right, but if I could tell you briefly, there are 13 projects that are now under construction either by private industry itself or in cooperation with the Government through the so-called second-round or third-round arrangements with which this committee is fully familiar.

Those 13 projects will produce about 900,000 kilowatts. Added to the plants that are now operating and producing power, of which there are six or seven, we will have a total of about 1,050,000 kilowatts. These plants will come in progressively, the first one scheduled, as I said yesterday, in September of this year. They will come in progressively over the next 2 or 2½ years. I can supply for the record more intimate details.

Mr. JENSEN. Please do that.

(The matter referred to follows:)

	Electrical output-net	Full power operation
	Kilowatts	
Private:		
Consolidated Edison	163,000	1961.
Vallecitos boiling water reactor	5,000	1957 (October).
Dresden nuclear power station	180,000	1960 (June).
Humboldt Bay project	50,000	1961 (mid).
Subtotal	398,000	
Cooperative:		
Yankee Atomic Electric Co	110,000	1960 (late).
Power Reactor Development Co	90,000	1961 (September).
Hallam nuclear power facility	75,000	1962 (June).
Rural Cooperative Power Association	20,000	1961 (June).
City of Piqua	10,500	1961 (December).
Northern States Power Co	62,000	1962 (fall).
Carolina-Virginia Nuclear Power Associates, Inc	17,000	1963.
East Central and Florida West Coast Nuclear Power Group	50,000	1964 (fall).
Philadelphia Electric	40,000	1964 (June).
Subtotal	474,500	
Total	872,500	

WATER-COOLED REACTOR

Mr. JENSEN. Mr. Chairman, would you say that the water-cooled reactor has been almost completely perfected?

Mr. McCONE. No, not by any means, sir. The water-cooled reactor divides itself into two concepts.

Mr. JENSEN. What is the difference between a water-cooled reactor and a boiling water reactor?

Mr. McCONE. The water-cooled reactor divides itself into two concepts. The pressurized water reactor of a type that Admiral Rickover had put into his submarine and which was installed at Shippingport

and is being installed at Yankee and at Indian Point, and the boiling water reactor which was installed in the Borax experimental plant and in the experimental boiling water reactor at the Argonne and at Dresden and at the Humboldt Bay plant of the Pacific Gas & Electric.

Those are two different concepts of water-cooled reactors. The pressurized water reactor is, let us say, nearer perfection than the boiling water reactor for the reason that a great deal of work has been done at Shippingport and in the submarines, but nevertheless in this study of an advanced pressurized boiling water reactor, which was authorized by this committee last year, the study was completed and was one of the studies reported on 2 or 3 days ago.

It is significant that in order to bring the cost of power down to the level of 8 or 9 mills that I mentioned will require an estimated expenditure of $8 or $9 million for further research and development in perfecting the fuel elements and also the components.

That is one of the reasons Dr. Pittman indicated to you that our program for increased expenditures in research and development of the fuel cycle are contemplated for 1960.

Mr. JENSEN. Your request for those funds is in this bill?

Mr. MCCONE. Yes, sir. Turning to the boiling water reactor, we find that the power density of the reactor must be increased and other improvements made in the way of circulation, and so forth.

Mr. JENSEN. That is in order to get more power from——

Mr. MCCONE. From a given reactor. For that reason we propose that, among other things, we build or arrange to have built as quickly as possible a prototype high-density boiling water reactor because we know that from the results of our work at Argonne and elsewhere if we do this, we can get a very much greater power output out of any reactor of a particular dimension or to get the same power we would have a smaller plant. This is what we seek.

Mr. JENSEN. And the cost of the power would be reduced?

Mr. MCCONE. Yes, sir.

ENGLISH BREEDER PLANT

Mr. JENSEN. Congressman Rabaut, of Michigan, a member of this committee, and I were delegated to go to England by this committee 2 years ago to look into the atomic power reactor program of England. It was most enlightening and interesting and educational. We went to Dounreay on the northern coast of Ireland, as we did to other reactor plants in England. At that time, 2 years ago, they told us the breeder plant they were building there was about 85 percent complete. That has been 2 years ago almost. They were very enthusiastic, the Atomic Energy Commission of England, about the possibilities for that plant.

Do you know what the status is of that plant as of today or recently?

Mr. MCCONE. Yes, I know. I was in Dounreay in November of last year. I went all over that plant. I have had a number of discussions with Lord Plowden and Sir Willim Cook on that plant since then. The plant is scheduled to go into initial operation sometime this year. It would not surprise me to see an announcement in midsummer that the plant has been closed up and initial operation started.

They tell me they will spend a considerable time, perhaps a year, bringing the plant up to full criticality and therefore full operation,

and then will operate it for some period of time before they will make their next step forward in the way of building a larger prototype. They have great hopes for the ultimate success of that breeder, just as we have.

EXPERIMENTAL FAST BREEDERS

We are paralleling what they are doing. As you know, some 2 or 3 years ago or longer you authorized the building of an experimental fast breeder, which was built by the Argonne Laboratories out at Arco, Idaho. It has operated and has answered a great many questions. We have now under construction the second experimental breeder that Dr. Pittman discussed previously, yesterday. That plant will be completed next year. That will be not only an advanced experimental breeder and will produce electricity, but it will also have an integral part of the plant being the complete reprocessing of the fuel elements, which is an extremely important part of a fast breeder operation.

Concurrently, the PRDC plant under construction up in Michigan by a private group is scheduled for completion sometime in late calendar 1960. Progress is quite satisfactory. We have licensed it after some considerable argument, as you know.

I, therefore, feel that our work in this area is paralleling, and if I may say, it is somewhat more advanced than the British.

Mr. JENSEN. You say you are somewhat more advanced than the British on the breeder concept?

Mr. MCCONE. Yes; no question about it. We have had one operating for some time. We not only have a second one well advanced in construction but we also have the big plant well advanced in construction.

One final thing, Mr. Jensen. We have a complete exchange of information with the British in this area.

Mr. JENSEN. They were very wonderful to us when we were over there.

Mr. MCCONE. Not only at governmental level but also the power company and engineering firm involved in the Detroit plant have their own arrangements. It is working out very well.

EXPLANATION OF FAST-BREEDER CONCEPT

Mr. JENSEN. What are the advantages claimed for the breeder concept over other concepts? Just how does that come about? Can you explain that in not too many words?

Mr. MCCONE. I should call upon a nuclear physicist to go into that, sir.

Mr. JENSEN. They claimed over there that it was almost perpetual motion, that as the atoms were split and separated, so to speak, that they would throw off the power and that would create more atoms to be split and throw off more power, and it was almost perpetual motion in the atom field. Our good clerk here was with us.

It was always difficult for me to fathom how this chain reaction of breaking down the atom would continue on and on and create more power. That is why they call it the breeder concept, I guess. You would not attempt to explain the whole thing in very common words, would you?

Mr. McCone. Dr. Pittman will, but before he does there is a great deal of difference between perpetual motion and almost perpetual motion.

Mr. Jensen. I guess that is right. Dr. Pittman, would you care to explain it?

Dr. Pittman. I will try to do it. It is very simple.

Mr. Jensen. Yes, I am sure it is.

Dr. Pittman. It is just difficult to explain. You recall the other day we talked about one neutron hitting one atom of U^{235} causing it to split. You recall that when it did split, several neutrons were released, let us say three. All you need to keep the chain reaction going is one of those three. If you have one going in splitting the U^{235} atom and three neutrons coming out and one of those neutrons is used to split another U^{235} atom, to cause the chain reaction just to keep going, you have two extra neutrons left over.

You started out with one, you have two now left over not needed to make the chain reaction continue. If those two neutrons or some fraction of those neutrons can be absorbed in U^{238}, which is the major portion of the uranium in the reactor, only a little U^{235}, most of it is U^{238}, if some portion of these extra two neutrons that are released as the result of a fission can be absorbed in the U^{238}, for every neutron that is absorbed you get an atom of plutonium. Plutonium is just as good—please let me use the word loosely—is just as good for fissioning as is U^{235}. Whereas, you split one atom of U^{235}, you have formed at least one more atom of plutonium, if you only use one of these two neutrons. If you use two of the two neutrons available, you form two atoms of plutonium for each atom of U^{235} split.

You start with one atom that is capable of releasing power, you release the power from that one atom, you have a neutron that goes on to release power from another atom of U^{235}, and each time you produce under ideal conditions two atoms of plutonium.

Each of those two atoms of plutonium is just as good as the one atom you started with. You are breeding in my idealized case on a 2-to-1 ratio. Actually, you lose some neutrons and you cannot get them all in. Maybe you might not get but one and a fraction of the two absorbed, but as long as you get more, as long as you absorb more neutrons than one in the uranium to form plutonium, you are creating more atoms of plutonium than you burned U^{235} and you are breeding in this system.

The problem is to make the reaction go in the way you do not lose the neutrons to something that is not making plutonium, and also so that it gets enough plutonium formed so that the losses in chemical processing do not make you back below the one level. It is a very simple situation, as I say, sir.

Mr. Jensen. I thank you, Doctor, for helping me again to partially understand.

Mr. Cannon. Dr. Fenton.

STATUS OF PENNSYLVANIA POWER & LIGHT CO. COOPERATIVE ARRANGEMENT

Mr. Fenton. Mr. Chairman, on page 78 of the justifications you referred to the summary of authorizations funded for cooperative arrangements and listed among those that are cooperating in the Penn-

sylvania Power & Light Co., of Pennsylvania. Just what is the status of that work?

Mr. McCone. It has been canceled. The reason for that is that that project was in the area of the fluid reactors. Research and development work had been carried on by the Pennsylvania Power & Light and Westinghouse Electric Co. under an arrangement which was authorized last year that would proceed for 2 years in the field of research and development at a cost, I believe, of $7 million. Then at then end of 2 years it was to be reviewed and a decision made concerning the construction of a plant. The Pennsylvania Power & Light people and the Westinghouse people last December came to the conclusion that even with an additional year of work, the construction of a plant would not be indicated, that a further research program would have to be undertaken with many problems to be solved. They came in and reported that to us and made a determination quite on their own that it would not be in their interests or in our interests to proceed along the line of the arrangement which had been agreed upon earlier.

Mr. Fenton. Certain expenditures had been made?

Mr. McCone. By them; yes.

Mr. Fenton. Not by the Government?

Mr. McCone. Not by the Government.

Mr. Fenton. Is that a case of going ahead too fast before sufficient research had been done?

Mr. McCone. No; I think it was a case of the research and development work being done indicating that more research had to be done before construction should be started.

Mr. Fenton. What would be the status of that kind of work at this time?

Mr. McCone. We are in this budget requesting $7.5 million for research and development work in the aqueous homogeneous field, and this work will be carried on under the Oak Ridge Laboratory. It will involve some work in this particular concept, which was a slurry as contrasted with a straight aqueous homogeneous solution. Some of the equipment used by the Pennsylvania Power & Light and Westinghouse is to be transferred to Oak Ridge.

REACTORS AS INDUSTRIAL HEAT SOURCE

Mr. Fenton. Last year I had a little colloquy about this. In your cooperation with the Interior Department, how has your thermonuclear research progressed in the past year, especially as it concerns sea water?

Mr. McCone. We have during the past year done a considerable amount of research and development work. We have requested and there is included in the authorization bill and we are asking for funds to build a reactor for producing heat. We plan to use that in conjunction with a saline water purification plant of the Department of the Interior.

The State of California has expressed a great deal of interest and probably some financial support of the whole thing. This will

demonstrate the value of nuclear energy as a source of industrial heat as contrasted with power. That is one of the projects we intend to proceed with as a construction project in fiscal 1960.

Mr. FENTON. I recall that takes a great deal of heat.

Mr. MCCONE. It takes a lot of heat.

Mr. FENTON. You say there is legislation in progress now?

Mr. MCCONE. It is included in the authorization bill. The authorization bill provides for a reactor for production of heat, and it permits us to do this cooperatively on a saline water purification program if we so desire. That is one of the line items in the bill. It is included in this section 111, item 60(e)14. It is treated in some considerable detail on pages 14 and 15 of the bill. Also, it is referred to in section 101(e).

Mr. FENTON. For my part, that will be certainly a wonderful addition to your accomplishments. We are spending a good many millions of dollars now in the Interior Department trying to find ways of converting saline water to potable water.

Mr. MCCONE. I hope someday we can find even a better way to do it than this, such as ionization or something.

Mr. FENTON. I suppose we are grasping at any straws along that line. That is all, Mr. Chairman. Thank you.

PHYSICAL RESEARCH

Mr. CANNON. Turning to "Physical research," the amount is $153,280,000. I shall ask the clerk to insert pages 130 through 151.

(The pages follow:)

PHYSICAL RESEARCH PROGRAM—OPERATING COSTS

Program statement

Estimate fiscal year 1960	$153,280,000
Estimate fiscal year 1959	119,000,000
Increase	34,280,000

Within the physical research program basic investigations of the natural laws are undertaken that have special relevance to the Commission's activities and responsibilities. The investigations are in the fields of physics, mathematics, chemistry, metallurgy, and controlled thermonuclear research and are undertaken to improve our command of nuclear technology and to accelerate and expand the developments of the uses of atomic energy. In retrospect, every advance in atomic energy capability can be traced to laboratory research of the type proposed under this program. About 70 percent of the program is carried on in the Commission's laboratories. Nearly all of the remaining portion is contracted to university laboratories where the work is closely integrated with postgraduate training in research.

The Commission's physical research program has three major objectives: (1) To increase our knowledge of the fundamental laws of nature; (2) to apply this new-found knowledge to the research and development work of the atomic energy program; and (3) as an important byproduct of research to train additional scientists and engineers so that scientific manpower will be available in future years for the continued assault on the many problems that need to be pursued. The amount of $153,280,000 is estimated in fiscal year 1960 to meet the most pressing research requirements. Under this program there appear for the first time estimates for controlled thermonuclear research heretofore budgeted under the "reactor development program." The controlled thermonuclear effort has been transferred to the physical research program in recognition of the more fundamental nature of the work.

Summary of estimates by category

Category	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
1. High energy physics	$15,479,774	$21,163,000	$28,908,000
2. Nuclear structure and neutron physics	12,214,097	14,170,000	15,943,000
3. Extranuclear properties of matter	716,784	761,000	935,000
4. Design and development of devices for physics research	3,068,439	5,255,000	6,986,000
5. Physical methods of isotope separation	718,856	1,056,000	1,217,000
6. Computer development and mathematics research	1,887,354	2,783,000	3,624,000
7. Process chemistry	5,561,743	5,410,000	5,936,000
8. Classified project A	1,349,290	0	0
9. Chemical properties and reactions	14,761,752	17,940,000	21,573,000
10. Chemical isotope separation studies	525,518	693,000	1,020,000
11. Special projects	0	2,063,000	2,451,000
12. Preparation and purification of special research materials	350,939	616,000	820,000
13. Production, treatment, and properties of materials	2,121,542	2,593,000	3,008,000
14. Alloy theory and the nature of solids	3,566,141	4,594,000	5,386,000
15. Effects of irradiations on materials	1,477,745	2,169,000	2,906,000
16. Controlled thermonuclear research	18,424,421	28,000,000	36,000,000
17. Equipment not included in construction projects	8,361,141	9,734,000	16,567,000
Total physical research program	90,585,536	119,000,000	153,280,000

JUSTIFICATION OF CATEGORIES

1. *High energy physics, $28,908,000*

High energy physics is one of the most active fields in contemporary science, and one that has attracted many of the best experimental and theoretical scientists throughout the world. In a sense, it is the most fundamental branch of physics, since its aim is to discover and investigate the elementary particles from which all matter is made. Many elementary particles are now known: the majority, after being formed, quickly change into other particles. Thus, in order to investigate their properties, the experimenter must have means for continually creating these unstable particles in the laboratory. This is done with high-energy particle accelerators by converting the kinetic energy of accelerated protons or electrons into an equivalent mass of new particles. In addition to producing new particles by going to increasingly higher energies, the details of the interactions between nuclear particles can be determined at shorter and shorter nuclear distances. At present no satisfactory theory of nuclear interactions exists, but with additional experimental data it is hoped that such a theory will ultimately be developed. Already many surprising and unexpected results have been obtained, as may be judged from the discovery of a large class of unstable particles, commonly referred to as the strange particles, which were unknown a few years ago. Experiments utilizing high-energy protons and electrons continue to show promise of producing further advances that will significantly contribute to our understanding of the nucleus as a whole.

To carry out such research, it is clear that the first requirement is an accelerator producing high-energy protons and electrons. Thus, this category includes support for the operation of the Bevatron at the Lawrence Radiation Laboratory (a 6-Bev. proton synchroton) and the Cosmotron at Brookhaven National Laboratory (a 3-Bev. proton synchotron). In addition, provision is also made for the operation of several electron synchrotrons and proton synchrocyclotrons of lesser energies. The latter machines do not have the capacity for producing the "strange" particles, but they do generate "pi" mesons, which are particles that contribute very significantly to the forces that hold nuclei together.

Nuclear interactions at high energies lead to very complex events, with the result that highly complicated experimental arrangments are needed to make precise measurements. Moreover, since smaller distances are involved, the likelihood of any process occurring in a given region is very small, so that particle detectors must be made much larger than those used at lower energies. Equipment used in experiments include bubble chambers (most of which are filled with liquid hydrogen at temperatures lower than —400° F.) for detecting series of events, scintillation counters for detecting and discriminating between particles passing through the counter within one hundred-millionth of a second of each other, and Cerenkov counters for measuring the velocity of particles moving in excess of the speed of light in the medium. Thus, in addition to the very high cost of operating the accelerators, the experiments utilizing the ac-

celerators are themselves quite costly. The research in this category is carried out both by groups permanently located at the accelerator site and by offsite contractors and other interested groups who visit the laboratory to set up the experiment and then have a "run" on the machine.

It is foreseen that under the research operations there will be substantial problems in analyzing the vast amounts of data accumulated. With the use of the above-mentioned detecting systems, it will be necessary and desirable to enlist the support of a number of university groups to cooperate in coping with problems of experimentation and data analysis. Some of these groups are being organized during fiscal year 1959 as a result of the increased support already provided. Their continued requirements for financial support will increase as more and more high-energy accelerators come into operation.

At this time four additional high energy accelerators, each of which has certain unique features, are under construction. These four accelerators include a 3-Bev. high intensity proton synchrotron at Princeton University (as a joint effort with the University of Pennsylvania), an electron synchrotron of 6 Bev. at Cambridge, Mass. (a joint venture between Harvard University and Massachusetts Institute of Technology), a 30-Bev. proton synchrotron at Brookhaven National Laboratory, and a 12.5 Bev. proton synchrontron at Argonne National Laboratory. Of these, Princeton and Brookhaven machines are scheduled for completion during fiscal year 1960. As a great deal of preliminary planning and a long lead-time is required to carry out significant experiments at these energies, efficient utilization of the machines dictates that a sizable research effort be begun long before completion of the machines. In order to provide for effective research programs with these new machines and with existing machines, an increase of $7,745,000 is required for fiscal year 1960.

2. *Nuclear structure and neutron physics, $15,943,000*

This category includes research relating to low energy nuclear processes. One of the important activities is the nuclear cross section measurements program. The various nuclear cross sections—total, capture, scattering, reactions, etc.—are measured for nuclei for incident neutrons, protons, alpha-particles, etc.—with energies from thermal through the million electron volt range. Acceleration of the incident charged particles and production of the neutrons are obtained by means of cyclotrons, electrostatic generators, synchrotrons, and other types of intermediate energy accelerators. In addition, a number of nuclear reactors are used as intense sources of neutrons for the thermal and epithermal range. A number of crystal spectrometers, choppers and time-of-flight detection equipment have been developed and are used for obtaining monoenergetic neutrons. The cross sections program includes measurements of the fissile nuclei to reactor technology.

Information on nuclear structure is also obtained under this category from beta ray spectrometry, scintillation spectrometry, mass spectroscopy, nuclear moment measurements, and theoretical studies. This knowledge is important from a basic standpoint and of immediate interest to reactor and weapons design. This information assumes an important role in attempts to develop theories of nuclear structure and test various proposed nuclear models.

Besides the programs at the national laboratories, approximately 45 universities are engaged in this research. The studies range from those using modest equipment for studying radioisotopes to those using a heavy ion accelerator at Yale for studying coulomb excitation, neutron transfer reactions, and other subjects.

An increase of $1,773,000 is required for this category. This increase results from the higher support of staff effort at the national laboratories and the requirements for operation of a number of new accelerators at university sites. During fiscal year 1959 a more vigorous pursuit of several promising areas of research will produce results that should be further investigated through fiscal year 1960. Further, there will be a number of new developments and facilities which must be fully utilized. Examples are the neutron velocity selector program that will be in operation with the new research reactor at Oak Ridge National Laboratory, and the fast chopper program with the new improved resolution system at Argonne National Laboratory.

For fiscal year 1960, funding will be provided for the initial equipping and operating costs of various low energy accelerators at university sites. The 10 Mev. Tandem Van de Graaff (the first U.S. machine of this type) will be in operation at the University of Wisconsin. At Yale University, a high current electron linac will replace the existing obsolete machine, and at the University

of Colorado, assembly of the 30 Mev. variable energy cyclotron will be completed. The 32-Mev. proton linac transferred from the Lawrence Radiation Laboratory to the University of Southern California is being reassembled and operation will commence about July 1959.

3. Extra nuclear properties of matter, $935,000

This category includes research on extra nuclear properties of matter at Oak Ridge National Laboratory, Argonne National Laboratory and approximately six universities. Included are such studies as optical spectroscopy, mass spectrometry, behavior of low energy ions in matters, magnetic resonance techniques and low temperature phenomena. The work is directed toward the improvement of the methods of study and the application of the methods to various fundamental problems.

4. Design and development of devices for physics research, $6,986,000

Progress in nuclear physics research is greatly dependent on the availability of good research tools. The tools and devices used in nuclear physics such as particle accelerators, research reactors, detecting devices, and analyzing equipment, can be extremely complex and costly. Support of this program is continued in order to assure that adequate tools are available to physicists in future years and that existing facilities, or those under construction, can continue to be improved for optimum research use. Phases of this program are supported at Argonne National Laboratory, Oak Ridge National Laboratory, Brookhaven National Laboratory, Lawrence Radiation Laboratory, Midwestern Universities Research Association, and several universities, including Stanford University.

The increase of $1,731,000 provides primarily for initiation of development work on the linear electron accelerator at Stanford University.

5. Physical methods of isotope separation, $1,217,000

Supported under this category is the work at the Oak Ridge National Laboratory providing for the electromagnetic separations of the isotopes of thorium, uranium, and plutonium on a continuing basis. These samples are important for the cross sections program, fundamental physics research, and numerous specific reactor physics studies. The samples are available for all Commission research programs. Also included in this activity are two university programs directed toward the development of techniques and processes for the separation of isotopes. Here, new physical methods for isotope separation are evaluated and developed to a point where, if the proposed process appears economically feasible, it can be further exploited.

The increase of $161,000 planned for fiscal year 1960 provides for (1) the further development of a certain method of isotope separation where the technical knowledge now shows that an increased study and effort is definitely warranted, and (2) the additional research and development effort on equipment and techniques to be utilized in the expanded stable isotopes production facility at Oak Ridge which was authorized and funded in fiscal year 1959.

6. Computer development and mathematics research, $3,624,000

The highly complex and interrelated nature of the Commission's programs has led to considerable dependence on the use of high speed automatic computers in many phases of its activities. Numerical computations are of growing importance in nuclear research, the design of accelerators, reactors, weapons, production scheduling, operations analysis, meteorology, and many other applied activities. This category provides research support behind the computing services at the national laboratories, the operation of the computing center at New York University, the development of advanced computers at the University of Illinois, Rice Institute, and the University of Chicago, and studies of improved computer components at Duke University and General Electric Co.

There is an increased requirement in this category of $841,000 for additional effort in this field. During fiscal year 1960, two and possibly three of the computers currently under construction will be completed and the research programs initiated. Additional computer services furnished by the New York University computer and applied mathematics center for the Division of Research will require an additional $260,000 in fiscal year 1960.

7. Process chemistry, $5,936,000

This category covers both basic and applied laboratory work related to separations processes; analytical and physical chemistry directed toward reactor-

chemistry; feed materials and fuel reprocessing problems and basic studies of unit operations.

A background of such research is essential to the pursuit of the successful application of nuclear technology to the many reactor, chemical processing, and materials problems of the Commission's reactor, production, and weapons programs. The physical and inorganic chemistry of a system must be understood in order to select intelligently the process variables which must be studied and evaluated, and finally the basic chemical engineering unit operations must be understood and studied independently in order to arrive at successful application in equipment and plant design. These chemical technology studies underlie all Commission programs in applied chemical engineering and provide the flexibility necessary for a strong development effort under other Commission programs. This category also provides the very important link between the basic research programs in chemistry in the Commission's laboratories and universities, and the highly specialized development projects.

A few examples of the kinds of research which are undertaken in this category are: (1) evaluation of ideas for new separations processes on a preliminary laboratory basis; (2) development of analytical methods, such as paper chromatography, gamma ray spectrometry, X-ray spectrometry, colorimetry, neutron activation, etc., for use in the development of nonaqueous techniques for fuel reprocessing, including high temperature methods; (3) research directed toward obtaining general fundamental physical chemical data pertinent to specific fuel systems; (4) fundamental investigation of slurry systems as potential fuels, e.g., uranium dioxide and thorium oxide in liquid metals and aqueous suspensions; (5) investigation of ion exchange and solvent extraction processes for improvement of existing systems and for new applications; (6) long-range studies of the process chemistry of elements produced during neutron irradiation of thorium under conditions of high irradiation and short cooling; (7) studies of factors influencing radiation decomposition of solvents employed in radio-chemical solvent extraction processes; (8) continued research on nonaqueous chemical processing systems such as pyrometallurgical, high temperature, and volatility methods, and (9) basic geological and geochemical studies related to the radioactive elements and their natural surroundings.

The increase of $526,000 provides for an increase in level of effort on the thorium-uranium 233 nonaqueous system work, and additional support for the offsite program in basic chemical and process engineering technology.

8. Classified project A, 0

9. Chemical properties and reactions, $21,573,000

Activities in this category encompass most of the basic research in the fields of chemistry which is the foundation of the chemical and chemical engineering activities of the Commission's program. Discoveries made in this research form the basis for progress in the practical application in current and future atomic energy technology. It is of vital importance to our future technological strength that there be a well-balanced and sound basic research program. This program serves also as the training ground for the people who will contribute to further scientific knowledge and to technological advancement.

Research being carried out in this category covers a very large number of different specific subjects which are often dependent on each other for steady advance in the knowledge of chemistry essential to the Commission's program. These subjects can be divided into the following categories:

(1) Nuclear chemistry includes isolation, identification, and the study of properties of various nuclides. These nuclides which are of particular interest include those of the naturally occurring heavy elements, all of which are radioactive, and those involved in, or resulting from, nuclear transformations which are brought about by interaction with high energy charged particles, neutrons, and protons. Usually such nuclides are radioactive and this property is the principal means used to study them. An increasingly important effort in nuclear chemistry is that devoted to studies of nuclear disintegation cause by multi-Bev. protons. The modes of disintegration and the effects produced on them by variation of proton energy and of target material are observed, and these results are compared with predictions derived from theory in order to test ideas on disintegration mechanisms. The establishment of detailed modes of decay of radioisotopes is a necessary and important aspect of nuclear chemistry; promising beginnings are being made on ultraprecise mass difference measurements as a tool in this work. Nuclear reactions induced by heavy ion (e.g., carbon,

nitrogen) bombardment are under intensive study at laboratories where such accelerating equipment is available. The program of investigation of the nuclear properties of the heavy elements is quite diversified and includes studies of the neutron interaction properties, nuclear energy levels, charged particle reactions, photofission, spallation and fission cross sections, fission kinetics, and various other phenomena.

(2) Radiochemistry, related to nuclear chemistry, is considered to be the application of radioactive isotopes to the study of a wide variety of chemical problems. In order to test theories about chemical behavior which are often most exact at low concentrations, tracer research with radioactive nuclides makes possible investigations of chemical phenomena which would not otherwise be accomplished. These techniques are also applied to many difficult analytical and metallurgical problems in the Commission's programs. The techniques of radiochemistry have proved invaluable in elucidating the complicated reaction mechanisms of chemical systems, which give information related to rates of reactions and means of catalyzing certain processes.

(3) Radiation chemistry seeks to determine and interpret the chemical effects of the various types of ionizing radiation such as alpha, beta, and gamma rays, fission recoils, neutrons, and X-rays. The number of systems of interest increases as the atomic energy program grows. Closely related to this is "hot atom" chemistry which deals more specifically with the chemistry of the recoiling of nuclei produced by a nuclear transformation. The basic work in radiation chemistry is directed at the characterization and measurement of the yields of reactions caused in chemical systems by ionizing radiation and the testing of mechanisms advanced to explain these effects. A second phase of the study of radiation effects is directed toward achieving an understanding of the processes involved in the potential utilization of radiation energy for promoting chemical reactions and altering the properties of high molecular weight molecules. Studies will be expanded in areas where the knowledge is least well understood, e.g., catalysis. Other studies underway include radiation decomposition of aqueous solutions during boiling; diffusion kinetics related to recombination of free radicals formed in irradiation and to reactions of free radicals with solute; radiation induced reactions in gases at high pressures (2,000 p.s.i.); and radiolysis of various organic materials.

(4) General physical and inorganic chemistry studies are those which investigate the behavior of chemical species and their solutions. Very often the goals of such studies are to obtain thermodynamic and kinetic data which give information useful in predicting those reactions which will take place, and those mechanisms by which the reactions will proceed. The structure of chemical substances is studied by neutron diffraction, optical spectroscopy, and magnetic methods. Mass spectrometric techniques are also advantageously used. One of the newer techniques which is being applied in nuclear magnetic resonance. Studies of the interaction of the free electron pairs in certain organic phosphorous compounds with thorium have provided useful information on bonding. Heats of formation of compounds of specific interest to programmatic problems (e.g., plutonium fluorides) are being measured in an adiabatic calorimeter. Vapor pressure measurements of volatile heavy elements fluorides are continuing and have added much to the data which will enable prediction of chemical behavior in various systems.

(5) High-temperature chemistry, because of its importance, the difficult techniques which must be employed, and lack of existing data, is considered a special field separate from the general fields of physical and inorganic chemistry. New reactions are being investigated and new substances are being prepared, and important quantitative data are obtained which are necessary to our understanding and application of materials and reactions at high temperature. The measurement of high-temperature thermodynamic and related properties of substances continues with emphasis directed toward accurate measurement of free energies of formation. A number of gaseous compounds, such as oxides and sulfides of uranium, thorium, plutonium, protactinium, tungsten, zirconium, hafnium, tantalum, and other high-temperature materials are being studied by effusion and other techniques. Heat capacities and heats of reaction at high temperature are being measured in an adiabatic calorimeter. Comprehensive studies on the binary phase equilibria of the five alkali metals with their salts is proceeding. Definite relationships are being demonstrated between fundamental properties, such as atomic size, and the degree of miscibility in the liquid state of a metal with its salt. Measurements of electrical transport

phenomena have provided a better understanding of the structures of many metal-fused salt systems.

(6) Basic analytical chemistry is designed to investigate the phenomena involved in the practice of analytical chemistry under the wide variety of conditions and in the numerous systems required by all phases of the Commission's program. Problems of particular importance include the determination of oxygen and nitrogen in metals, the analytical chemistry of fluoride systems, of thorium, and of certain organic compounds. Spectrographic techniques are widely applied, and their proper application requires preliminary research and development. Emission, infrared absorption, and X-ray fluorescence spectrometric techniques are all used. Other analytical techniques which are being studied are: potentiometric and complexometric titrations, ion exchange separations, colorimetric determinations, and photometric titrations. Isotopic dilution, activation analysis, and other nuclear techniques are proving to be extremely useful and versatile.

(7) Attempts are being made, in studies of isotope effects, to gain a more complete understanding of the behavior of isotopes and isotopically substituted compounds. Although the gross chemical properties of different isotopes are the same, there are subtle, but very real and very important differences in their chemical properties which are due to their differences in mass, in zero point energy, in their nuclear constituents, and in other quantitative effects. These differences and their chemical effects are being investigated both theoretically and experimentally. Fundamental research is conducted on chemical reaction kinetics, quantum structure, vapor pressure effects, and other basic properties related to isotope effects. Examples of studies of this type currently being carried out at the national laboratories and at offsite laboratories are the experimental and theoretical determination of the effect of isotopic substitution on the rate of reaction of hydrogen molecules with chlorine atoms, research on the intermolecular forces between isotopically substituted molecules, and measurements of the infrared spectra of isotopically substituted compounds.

(8) Organic chemistry is a relatively small part of the program, and is concerned with research on materials and techniques of specific interest to the Commission. The tritium beta-induced exchange progress has become a widely used method for the preparation of tritium-labeled compounds; the application of this method to additional classes of compounds, and the mechanism of the methods, must be studied further. A study of the organic chemistry of carbon surfaces has been initiated, in order to investigate the possibility of free radical formation at such surfaces. The structure and stability of organometallic compounds are being studied. Investigations are also being carried out on the preparation and properties of organophosphorous and organonitrogen compounds of interest in the chemical processing program, and on the dispersion of the metallic compounds in organic solvents.

The fiscal year 1960 estimate of $21,573,000 for this category represents an increase of $3,633,000 over fiscal year 1959. Those areas in which increased effort is being applied are: nuclear chemistry, particularly the study of the nuclear and chemical properties of the isotopes of the heaviest elements (increase of $1,135,000); investigations of properties and behavior of chemical systems at high temperatures (increase of $700,000); and study the effects of all types of radiation on chemical systems under a variety of conditions (increase of $680,000). The remainder of the increase ($1,148,000) is required for strengthening the program of general physical and inorganic chemistry related to the interest of the Commission.

10. Chemical isotope separation studies, $1,020,000

In its continuing effort to develop more economical methods of enriching and separating isotopes needed by the Commission, basic and applied research is conducted at universities and national laboratories which will lead to a better understanding of isotopic fractionation processes. Studies are carried out on the thermodynamic, spectroscopic, kinetic, and chemical properties of isotopically substituted compounds. Chemical exchange, ion exchange, distillation, and other physicochemical methods of isotope separation are investigated. Research included in this category also covers isotope assay work necessary in the isotope separation program. Reliable techniques must be developed for background and impurity corrections that have to be applied to these assays.

The increase of $327,000 estimated in fiscal year 1960 is for the development of new methods of isotope enrichment such as gas chromotography, liquid-liquid

extraction, new ion exchange and chemical exchange processes, and for advanced experimental facilities and pilot plant scale separations of hitherto unavailable isotopes of importance to the AEC program. Approximately $200,000 of the estimated increase is for development of new apparatus to be set up to enrich oxygen-17 and oxygen-18 isotopes; currently, all oxygen enriched in these heavier isotopes must be imported from abroad. The idea of combining complex formation with ion exchange in the separation of isotopes needs to be thoroughly investigated and work on this will be increased. New isotope analytic techniques will also be developed.

11. Special projects, $2,451,000

The narrative for this category is contained on classified page 152.

12. Preparation and purification of special research materials, $820,000

This activity is being established in fiscal year 1960 to bring together the costs for the manufacture, recovery, purification, separation, and concentration of research quantities of isotopes and materials for the physical research program (chemistry, physics, and metallurgy). Typical items included within the scope of this category are as follows: Investigation of new radioisotopes produced by either a nuclear reactor or an accelerator; study of unusual nuclear reactions, (neutron-helium-3) (triton-proton) (triton-neutron), for obtaining higher-specific-activity and carrier-free radioisotopes needed for cross-section measurements and for studies of ion-exchange behavior, chromatography, and chemistry of less familiar elements; investigation of the separation of radionuclides by phsyical processes: calutron, thermal diffusion, and electromigration in fused salts; improved method of xenon separation from krypton; investigation of new isotopes; development of production and separation processes for transplutonium elements and other heavy nuclides, and study of their behavior in existing processes; long range effort to obtain significant research quantities of transplutonium isotopes, particularly californium 252, including fabrication of plutonium fuel elements, reactor irradiations, chemical separations, reirradiation of separated products.

The increase in fiscal year 1960 provides for a transplutonium isotopes program that reflects the culmination of several years planning for increased basic research programs in the chemical and physical properties of the very heavy nuclides.

13. Production, treatment, and properties of materials, $3,008,000

Research on special materials of immediate or foreseeable interest to the Atomic Energy Commission is supported under this category. The unusually severe and unique conditions to which materials are subjected in atomic energy applications have necessitated the development of metals and their alloys which previously were scientific curiosities. As these applications are advanced and new concepts proposed, materials development is often found to be the major problem or the determining factor in feasibility. A broad attack is carried out on the general materials problem with particular emphasis on those materials of possible or predictable utility by the Commission.

Research on both fissionable and nonfissionable substances is supported. Examples of programs which are included are (1) studies of uranium and plutonium alloys, (2) research on methods of extraction and purification of special metals, (3) studies of the properties of possible high-temperature fuel materials, (4) studies of barrier materials, (5) corrosion studies and the development of corrosion-resistant alloys, and (6) research on the preparation of research quantities of high purity materials for use elsewhere in the overall program.

The increase of $415,000 proposed for fiscal year 1960 provides for increased efforts on plutonium metallurgy, fundamental and applied corrosion research, ceramics research, and on the preparation of pure materials with particular emphasis on high temperature crystals (oxides).

14. Alloy theory and the nature of solids, $5,386,000

The aim of this program of fundamental studies is the attainment of an understanding of the properties of materials, the origin of these properties, and the factors which are a chief influence upon them. The information obtained provides a foundation for the future development of new materials and is a prerequisite for the fundamental understanding of the influence of radiation on properties of materials. Major categories of activity are physical metallurgy,

physical ceramics, solid state physics, research on surfaces and surface films, and research on the nature of liquids. Examples of individual researches are high temperature thermal conductivity and diffusivity, X-ray and neutron diffraction structural studies of both liquids and solids, solubilities in liquid metal systems, the thermodynamics and structures of high temperature materials, alloy theory, the mechanisms and kinetics of reactions in the solid state, lattice imperfections—their origin and influence upon properties, recrystallization, and grain growth in ceramics, and the formation of surface films.

The increase of $792,000 planned for fiscal year 1960 provides for additional activity in the fields of solid state physics, physical metallurgy and ceramics. Increased emphasis is to be placed upon high temperature materials research, binding energies, thermodynamics of reactions in the solid state and oxidation and surface studies. The properties of materials at elevated temperatures are the least understood and are becoming increasingly important in the advancing technology of nuclear energy.

15. Effects of irradiation on materials, $2,906,000

One of the unique circumstances involved in the use of materials in the atomic energy program is the fact that they may be exposed to irradiation for prolonged periods. This condition can produce drastic changes in the behavior and properties of materials and restricts their selection. The research program in this field is devoted to three general areas: (1) An understanding of the theory and basic mechanism of the effect of irradiation on solids, (2) the effect of irradiation on the kinetics of metallurgical processes, and (3) a practical evaluation of the performance of certain materials under irradiation. Although considerable progress has been made in the field of irradiation effects, there still remain many difficult problems from both the fundamental and applied standpoint.

The increase of $737,000 planned for fiscal year 1960 provides for increased effort on applied research in radiation effects, solid state physics radiation studies (basic mechanism, etc.), and the effect of radiation on physical metallurgical reactions. Increased emphasis is to be placed upon theoretical aspects of the interaction of radiation and matter. Fundamental studies of the effects of radiation on thermoelectric power are to be initiated as is a study of the effect of very intense radiation fluxes upon the properties of solids.

16. Controlled thermonuclear research, $36,000,000

Research and development leading to the controlled production of power from the fusion of heavy hydrogen nuclei is being conducted at four major laboratories: Los Alamos Scientific Laboratory (LASL), Oak Ridge National Laboratory (ORNL), Princeton University's Forrestal Research Center, and the Lawrence Radiation Laboratory at Berkeley and Livermore, Calif. (LRL). Supporting work on specialized aspects of the program is carried on at New York University, the Naval Research Laboratory, and a number of universities and industrial organizations.

The controlled production of power from nuclear fusion requires that deuterium gas (or a deuterium-tritium mixture) be heated to a temperature of the order of 100 million degrees centigrade, and that the ionized gas (plasma) be confined long enough to permit an appreciable fraction of the fusionable nuclei to react, with the consequent release of energy. In all cases under active investigation magnetic fields are used to confine the plasma.

In attempting to create or establish the very hot plasma, a number of different methods show promise. Similarly there are several types of magnetic field configurations which can be employed. Consequently, the Commission's program is fairly broad and consists of several basic approaches to the problem. The relative merits of these several approaches and their relative potentialities for leading ultimately to a power producer cannot be clearly assessed at this time. However, theoretical and experimental work along all of these lines is contributing substantially to our current understanding of plasma physics. To a considerable extent the approaches complement one another by elucidating different facets of complex plasma phenomena. Experience has shown the absolute necessity of good experimental information on hot plasmas. Such information is obtainable only in rather elaborate devices.

The major approaches are as follows:

(1) *Pinch discharge* (LASL and LRL).—In this approach strong electric currents produced within the plasma itself generate the strong magnetic fields

which confine and compress the plasma. High-current discharges established in either linear or toroidal tubes pinch the plasma into a narrow column along the tube axis. Compression by the self-magnetic field heats the gas and raises its density.

(2) *Magnetic mirrors* (LRL).—Plasma is contained in a strong externally applied longitudinal magnetic field; strong coils at either end of a cylindrical chamber establish the magnetic mirrors which reflect the electrically charged plasma particles back into the central region of the magnetic bottle. The general method of heating is to compress the plasma by increasing the magnetic field strength.

(3) *Stellarator* (Princeton).—Plasma is contained in a strong longitudinal magnetic field produced in a closed (endless) tube by means of current-carrying coils surrounding the tube. A relatively complex coil configuration is required to produce stability and counteract adverse effects of the tube curvature. Initial heating is accomplished by comparatively weak currents passed through the plasma; further heating results from the application of strong radio-frequency magnetic fields.

(4) *Energetic-ion injection* (ORNL).—Very energetic molecular ions are injected into a DC magnetic mirror configuration. Breakup of these ions by a high-current vacuum arc results in the trapping of "hot" atomic ions. The problem is then one of containing these ions long enough for the ion density to build up. Energetic injection is a method of heating which is probably not confined to mirror geometries.

(5) *Astron* (LRL).—Plasma is to be heated and contained by means of a cylindrical layer of spiraling relativistic electrons established inside a solenoidal field.

In addition to these major approaches, there are small efforts along the following lines:

(*a*) *Rotating plasmas* (LRL and LASL).—Plasma is set in rotation by means of a radial electric field and a longitudinal magnetic field. Heating is by conversion of rotational kinetic energy into internal energy of the plasma. Devices now under investigation are the homopolar device and ion magnetron at the Lawrence Radiation Laboratory and the Ixion at Los Alamos Scientific Laboratory.

(*b*) *Stock heating* (collapse) (LASL and LRL).—Plasma is shockheated by the extremely rapid application of a strong magnetic field, usually a mirror-type field, and is simultaneously compresses toward the axis. Example: Los Alamos Scientific Laboratory's Scylla device.

Significant advances are being made along these several lines. Intensive work connected with the five major approaches has resulted in steady increases in containment time and/or plasma "temperature," as well as a better understanding of plasma behavior. Machines now in operation at Los Alamos, Oak Ridge and the Lawrence Radiation Laboratory should be capable of producing plasma at temperatures in the thermonuclear range. If they fall short of the design goal, their operation should point the way to suitable modifications and further progress. Princeton is engaged in the design and fabrication of the large model C Stellarator, which should open the way for a whole new range of significant plasma experiments.

Considerable attention has been devoted in the last several years to the problem of hydromagnetic plasma instabilities, and encouraging progress has been made toward controlling them. Emphasis is now shifting to the theoretical and experimental study of plasma oscillations, a form of instability associated with the presence of electric fields and currents in the plasma.

A comparison of the levels of effort at the several sites appears below:

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Los Alamos Scientific Laboratory	$2,355,114	$3,400,000	$4,950,000
Oak Ridge National Laboratory	3,337,982	4,400,000	6,600,000
Princeton University's Forrestal Research Center:			
Research program	3,538,571	3,700,000	6,040,000
Model C fabrication	1,358,000	8,200,000	8,079,000
Lawrence Radiation Laboratory	6,395,899	6,600,000	7,500,000
Washington	1,438,855	1,700,000	2,831,000
Total	18,424,421	28,000,000	36,000,000

At Los Alamos, work will be continued on the fast pinch devices of the Columbus and Perhapsatron classes, in order to understand the complex behavior of these devices. Further pinch work will probably be directed toward a radiofrequency pinch, rather than a large milisecond-range toroidal pinch. The increase of $1,550,000 planned for fiscal year 1960 provides for the radiofrequency pinch work, completion of the large condenser bank, installation of inductive energy-storage equipment, and fabrication of a second model of the Ixion (rotating plasma) machine.

At Oak Ridge, steady progress with the DCX–1 machine is leading to a larger and more versatile machine, DCX–2. Component studies and preliminary design will be undertaken in fiscal year 1959, and fabrication will begin in fiscal year 1960. DCX–2 will use a recently obtained high-current high-voltage power supply for injection, as well as a larger motor-generator magnet power supply which will be available in the new quarters in building 9201–2. In addition to providing for DCX–2 fabrication, the increase of $2,200,000 planned for in fiscal year 1960 will cover special arc studies aimed at a better solution of the ion-injection and wall-impurity influx problems, and also magnetic containment studies associated with the use of a time-rising field for compression. DCX–2 is expected to be capable of containing energetic charged reaction products essential to plasma ignition.

At Princeton, experimentation will continue with the small-scale stellarator devices in an effort to obtain more information on heating techniques and plasma loss processes. Model C costs are estimated to total $26 million over the period fiscal years 1958–61.

The increase of $2,219,000 planned for the Princeton research program in fiscal year 1960 will provide for the costs associated with preliminary experimentation with the model C research facility. First-stage operation of model C (without radiofrequency heating, divertor or high-speed pumps) is expected to begin in mid fiscal year 1960. Construction of laboratories, office space, and housing for model C are provided under construction project 58–e–6, Project Sherwood plant.

At the Lawrence Radiation Laboratory, the major effort is pursued at the Livermore site, with a smaller scale program at Berkeley. The diversified Lawrence Radiation Laboratory program emphasises work on mirror machines, pinch devices, and the Astron, with much smaller efforts on the rotating plasma and shock-heating machines. There have been continuous improvements in the capabilities of the mirror machines, particularly Toy Top, the multiple compression device, which has yielded particle energies in the thermonuclear range.

The several pinch devices at the Lawrence Radiation Laboratory differ markedly from those at Los Alamos Scientific Laboratory and are providing complementary information on the behavior of pinched plasmas.

Initial results on the Astron electron gun have been very encouraging. Solution of problems on injection and electron layer formation at low energy during fiscal 1959 may indicate the need for a more energetic injector and much larger field coils in fiscal year 1960. The increase of $900,000 planned for fiscal year 1960 at the Lawrence Radiation Laboratory provides for an intensification of mirror machine effort, with emphasis on a larger energetic-particle injection device, an expansion of the pinch program, an increase in the Astron program as it moves into the next stage, and increased effort on energy storage and switching systems and on high vacuum techniques.

Funds listed under the Washington portion of the controlled thermonuclear research budget provide for supporting research and development at off-site installations, both at universities and with industrial groups. This work includes general theoretical studies, experimental work on shock waves, development of diagnostic tools and techniques, development of specialized components such as capacitors, and work on ultrahigh vacuum techniques.

Increased effort in developing a better understanding or the physics of plasma, the fully ionized state of matter, is expected to occur. The recent declassification of controlled thermonuclear reaction research will have the effect of bringing a greater body of scientific talent to bear on the difficult problems involved. It is to be emphasized that this field of science is relatively unexplored and consequently holds much promise for important applications of new knowledge as it is developed.

17. Equipment not included in construction projects, $16,567,000

Equipment requirements for the physical research program are estimated at $16,567,000 for fiscal year 1960, which represents an increase of $6,833,000 over fiscal year 1959. The estimate is based on normal requirements as indi-

cated by past experience and on the needs of the expanding research program planned for fiscal year 1960. A major portion of the equipment provided under this category will support the physics, chemistry, metallurgy and controlled thermonuclear research programs being conducted at the various major laboratories. The remainder will support research being conducted through the contract research program at colleges, universities, and private laboratories throughout the country.

The equipment to be purchased includes replacement as well as equipment additions necessary to support the expanding program. Examples of the type of equipment include:

(1) Special fabrications and purchases of unique testing and experimental equipment for the high energy physics programs at Argonne, Brookhaven, and the Lawrence Radiation Laboratory and at several universities under the off-site contract research program. For example, at Brookhaven National Laboratory the first 30 beam magnets costing $1,950,000 will be required for the focusing, analyzing, and bending of 3 or 4 experimental beams from the alternating gradient Synchrotron. Procurement of the magnet for the 80-inch hydrogen bubble chamber and development of counting equipment will be initiated ($550,000), while additional experimental magnets and auxiliary equipment for the Cosmotron are also needed ($350,000).

In addition a 75-ton truck crane and a 50-ton low bed trailer will be required for moving and arranging the shielding blocks and research equipment in the experimental area outside the alternating gradient Synchrotron target building ($130,000).

At the Lawrence Radiation Laboratory the stepped-up physics research programs will require additional magnets and power supplies ($150,000), a special meson spectrometer ($300,000), additional and new and improved counting equipment ($250,000), and additional data processing equipment ($25,000). The new accelerators at Princeton and Cambridge will require a buildup in experimental equipment including steering and focusing magnets, liquid hydrogen facilities, counting equipment, automatic film scanning devices and bubble chambers for maximum utilization of these machines. The total estimated cost of the equipment required for the Princeton and Cambridge machines in fiscal year 1960 totals $2,500,000.

(2) D-O system for the Oak Ridge Research Reactor, $375,000.

(3) A 5 million electronvolt Van de Graaff for location at a university site, $600,000.

(4) Tandem Van de Graaff for location at a university site, $300,000. (The amount shown provides for the cost to be incurred in fiscal year 1960.) The balance of the cost ($900,000) is budgeted under the "Changes in selected resources" portion of the budget.

There follows a breakdown of the total equipment costs for fiscal year 1960 indicating amounts estimated for each installation in relation to its operating costs under this program:

[In thousands of dollars]

Installation	Other operating costs	Equipment costs
Stanford University	1,800	0
Lawrence Radiation Laboratory	23,734	2,326
Oak Ridge National Laboratory	19,035	3,140
Argonne National Laboratory	12,910	911
Brookhaven National Laboratory	12,165	3,983
Ames Laboratory	3,193	200
Princeton	14,119	920
Los Alamos Scientific Laboratory	4,950	127
Washington off-site program	39,474	4,600
Midwestern Universities Research Association	1,800	200
Atomics International	1,020	92
Knolls Atomic Power Laboratory	525	65
Sylvania Electric Products	150	3
New York University	1,500	0
Battelle Memorial Institute	138	0
Nuclear Metals, Inc	100	0
Phillips Petroleum	100	0
Total	136,713	16,567

Mr. CANNON. Mr. Chairman, after adjustment for comparability, you are requesting an increase of $27 million, $10 million of which you estimated last year would be necessary to annualize the 1959 increases allowed. Why do you need the other $17 million increase for 1960?

Mr. MCCONE. Mr. Chairman, Dr. Williams, who is head of our physical research program, is here beside me to answer these questions in detail because he is familiar with every detail.

VALUE OF PHYSICAL RESEARCH PROGRAM

I would like to say, however, that the physical research program is the very foundation and the hard core of our whole atomic program. It is the area in which we explore the nature of matter and it is the source of all of our basic developments. There have been constructed facilities, very large and very important, such as high-energy accelerators and some of them will come into operation during the year and a substantial part of this increase is to support the facilities which have been under construction and are now nearing completion.

In addition, there is a growth in several areas of activity of physical research and the composite results in the increase which you mentioned.

The Department of Physical Research was very careful in analyzing their situation. Their requirements were somewhat higher than we are presenting to you. The Commission, after careful review and a visit to all of the laboratories and facilities, reached the conclusion that this was about the proper balance of effort in physical research for this year. I would like Dr. Williams to discuss any particular points.

Mr. CANNON. Dr. Williams.

REASON FOR INCREASE REQUESTED FOR 1960

Dr. WILLIAMS. Mr. Cannon, with respect to your question, it is true that as testified last year, the annualization rate at this time would be $100 million for that part of the physical research program which was presented to you last year. Indeed, that turns out to be the case. To our best estimates, since the June costs are not presently with us, it will be very close to $100 million.

The second part of your question was to ask why was the increase in this physical research program, excluding the Sherwood program, necessary? The amount we are asking for in this program, exclusive of Sherwood, is $115,280,000. The difference between our annualization rate of $100 million and that figure is made up, as Mr. McCone has said, of a variety of things which are now about to come into operation. I have a list here, which I would be very happy to provide for the record, which shows those differences. As a result of those differences, it shows that there are no increases in our program of a base nature, that we are planning to run at essentially the same level that we are presently operating in 1959 if we receive the funds requested in 1960. There are no increases in the program.

Mr. CANNON. We shall be glad to have you include that in the record.

Dr. WILLIAMS. Thank you.

(The information referred to follows:)

	Millions
Program level (exclusive of Sherwood operating costs and equipment)—end of fiscal year 1959	$100.0
Add:	
1. Preoperational and equipment costs associated with multi-Bev accelerators authorized and under construction:	
Argonne zero gradient synchrotron	1.0
Brookhaven alternating gradient synchrotron	3.3
Cambridge electron accelerator	2.4
Princeton-Penn accelerator	1.9
Subtotal	8.6
2. Design studies associated with new accelerators:	
Stanford	1.8
Midwestern Universities Research Association	.4
Subtotal	2.2
3. Increased utilization of existing accelerators	1.7
4. Purchase of 2 Van de Graaff generators	.9
5. Increased capacity for special projects	.5
6. Initiation of research with computers under construction and increased utilization of existing computers	.8
7. Pilot plant for separation of oxygen isotopes and initiation of long-range effort to obtain significant quantities of transplutonium elements	.5
Total, amount estimated for physical research program (exclusive of Sherwood operating costs and equipment) during fiscal year 1960	115.2

PROGRESS IN CONTROLLED FUSION STUDIES

Mr. CANNON. Are there any notable accomplishments, Mr. Chairman, in the current year in your controlled fusion studies for which you are asking $8 million increase?

Mr. MCCONE. There has been substantial progress. There is evidence that we in the United States are more advanced in this field than are others.

We are carrying on a broader research and by comparison with the work of others—and this was given a very careful treatment at Geneva, as you know—we feel that we are making better progress and more progress than other nations.

Mr. CANNON. I am glad to hear you say that, Mr. Chairman.

Mr. MCCONE. I cannot say that there is at this point the breakthrough in the goal that we seek, and that is the production of energy through thermonuclear fusion, to control thermonuclear fusion. We have not obtained the temperatures that appear to be necessary. We have made encouraging progress but this is a much more difficult problem than was thought here 2 or 3 years ago when there was a wave of optimism that here was the final answer to the problem of nuclear power.

Mr. CANNON. I am very glad to hear you say we are making progress, Mr. Chairman. I am especially pleased that you say we are leading the world in these studies.

There are indications that Russia is specializing in this field and that they have reached the conclusion that the future progress will

be in fusion instead of fission, and that they are going to go into this matter perhaps more energetically than they have in the past and perhaps more energetically than we are pursuing it.

You do think that with this additional $8 million we are in a position to maintain that lead?

Mr. McCone. Yes, I think so. Let me say this: I think at this level of expenditure we have a very dynamic and very costly research program. I think that we are going to have to face the prospect of supporting this effort at this level for some years to come; that we are going to accomplish our goal.

What we intend to do is to provide in the four laboratories that carry on this work the funds for their research and for their equipment at a level approximating the level of this year.

Mr. Cannon. But indications are that the Russians are giving top priority to these studies.

The statement has been made, and it has been made in the press—you can take that for what it is worth, but it is astonishing how much these reporters give us that is dependable—that the Russians are devoting much greater resources in this field and are progressing more rapidly than the West. So it is gratifying and it is reassuring to hear you say we are ahead of them and are maintaining that lead.

Mr. McCone. As you know, this is declassified. We exchange rather freely with them and with the British. Our scientists have been over there and theirs are coming here. Perhaps Dr. Williams would like to comment on that.

Mr. Cannon. Dr. Williams?

Dr. Williams. The Russians are attacking this field in two ways, two technical ways which I would be very happy to have the opportunity to explain to you, whereas our approach is rather done in four ways. In that sense I think we are exerting a greater effort relatively than they are.

The details of what they are doing are not completely known to us, although we did have a very free exchange of information at Geneva last September. What they have done since that time we are not so well informed on.

As Mr. McCone has said, we are hoping that we can get further exchange of information with them and find out more about the details of what they are doing during this forthcoming fall by visits to Russia and ultimately by having some of them visit our laboratories.

I am confident that our effort, as of last September when we took a good reading on them, is more advanced than their effort, more intensive. At that time. we had every indication we were ahead of them in this game.

Mr. Cannon. Off the record.

(Off the record.)

Mr. Cannon. Back on the record.

You are asking large amounts of research. The amount spent by the Government in all branches of research has mushroomed incredibly. Just in the last few years we have dropped into the habit, whenever a problem was presented and we did not know what the answer was, or we had no remedy and did not have the courage or resources to apply the remedy, we would solve the problem by providing money for research.

Somebody would come in and say, "What about this situation? It needs immediate attention." We would say, "We are providing money for research," as if that disposed of everything.

We sometimes get the idea, at least the public sometimes gets the idea, that when you have invested money in research you can depend on getting a hundred percent value out of that research, when more times than not we get nothing.

It is something like the man who expects to drink health out of a bottle. He buys a bottle of medicine and because he pays for it and takes it according to directions, he expects to be restored to health beyond any peradventure.

There is nothing in which we have not wasted vast sums of money on research, not only in this line, but in all branches of the Government.

The committee would be glad if you would keep that in mind as you go along. It is some reassurance to the committee to know while we are spending and must continue to spend for research without any return whatever, there are instances in which we are getting some appreciable returns.

We should remember that merely because we invest money in research, that does not necessarily mean we are going to get anything out of it. It may pay a thousand percent, but too often it pays nothing.

OFFSITE CONTRACT RENEWALS, 1959

We should be glad if you would insert in the record at this point an up-to-date tabulation of off-site contracts, similar to that you gave us on page 1050 of last year's hearings.

Bring that table down to date, if you will.

Mr. McCone. Yes, sir.

(The information requested is as follows:)

Division of Research, offsite contract renewals, fiscal year 1959

Continuously in effect for—	Number of contracts renewed	Dollar value of contracts renewed
Less than 3 years	60	$5,068,447
3 to 5 years	140	5,436,960
5 to 10 years	135	9,441,653
10 or more years	28	6,106,146
Total	363	26,053,206

Mr. Cannon. Are there questions on physical research?

Dr. Fenton.

CHEMICAL AND METALLURGICAL PROBLEMS

Mr. Fenton. Mr. Chairman, is it not true that there are many chemical and metallurgical problems yet to be solved before we can expect to achieve competitive electric power from atomic powerplants in the United States?

Mr. McCone. Yes, that is true. There are a great many.

Mr. Fenton. What progress is being made on these basic research problems?

Mr. McCone. I think there has been very substantial progress in both metallurgy and chemistry. We have succeeded in developing materials which are capable of withstanding higher temperatures and maintaining their structural qualities under conditions of irradiation. This has made significant contribution to the reaction design, most particularly the cladding of fuel elements.

There has been significant advance in chemistry, one which has been mentioned here has been the moderator in the organic reactor which has now operated quite satisfactorily, indicating that we could safely proceed with the construction of the Piqua plant and also the building of a more advanced experimental reactor, for which we are asking funds this year.

We feel quite hopeful that there will be further advances in this particular field, and perhaps we can reduce, if not eliminate, the polymerization that takes place in the organic moderator, which is one of the worries of that process.

There are innumerable instances of advances which have made significant contributions to our power program.

THERMOCOUPLER PRINCIPLE OF GENERATING POWER

Mr. Fenton. What progress is being made in connection with direct conversion or the thermocoupler principle of generating power on a large scale?

What work is being done on this problem at this time? Are there any industry groups working on this?

Mr. McCone. Yes, there are. You are familiar with Snap Three, which was the small device in which the heat from radioactive decay was picked up in the thermocouple, and translated into electrical energy. This, we think, would provide for a power source for satellites and for other uses. There is quite a program going forward in this development.

With respect to the thermocouple you are familiar with the work reported from Los Alamos in which a gas was used as part of a thermocouple and power was developed from that source and this is a program which we are supporting at Los Alamos and the scientists out there have very considerable hope for the prospect, but do not diminish the fact that this is a very difficult problem.

There are men here who could discuss both of these rather advanced technical developments in great detail if you would like them to, Doctor.

FUTURE OF COAL

Mr. Fenton. I am certainly interested in the conversion from any source into electrical energy. I am particularly concerned to know about the future of coal.

If I understood you correctly in your statement about your objective in the use of electrical energy, you stated that you were trying to develop a method to bring the cost down in the production of electricity, to at least as cheap as electricity is now produced.

If you are just trying to bring it down to the present cost that it is now produced, I can see no point in going further.

However, if your thoughts are to reduce it to a lower cost, then I would think there might be some advantage to it.

I am certainly interested in coal, coming from a coal industry area, particularly anthracite coal and I am just beginning to wonder whether or not it is advantageous, and of course I am all for progress, but I am wondering whether it is advantageous to dislocate a lot of working people in the coal industry for something else.

Mr. McCone. Well, that is a very good question, Doctor, and it is one to which I have given a very considerable amount of thought. My views are this: That the energy requirements of this country are going to increase at the rate of doubling about every 10 years for the indefinite future. The needs of industry, the needs of our whole economy and the growth of population indicate about a 10-year doubling factor.

This is what the economists tell us and they seem to be able to support this assumption with good solid facts.

Now, we feel that atomic energy as a source of power is going to pick up a certain increment of that increase in the years to come. We do not in the foreseeable future see that it is going to replace coal, or for that matter, oil. However, it will take its place as an added source of energy and in that way it will make a great contribution to the economy and the welfare of this country and in doing so it will not dislocate other resources for energy. This, I feel very positive about. The future of the coal miner or the oil worker does not concern me from the standpoint of his being dislodged through the development of nuclear power.

Another matter: We are not always going to have coal in abundance nor are we always going to have oil. There are points where these resources are going to be harder to come by and therefore more costly and at that time the fact that we have developed nuclear power may be our salvation.

Mr. Fenton. Well, of course I realize that our reserves of coal are limited, but at the present rate of consumption, particularly anthracite coal, we have enough coal in my particular district to go for 100 or 125 years.

We are concerned about it. Of course, the House just a week or two ago—2 weeks today, I believe—passed a new research bill, trying to find, probably, new uses for coal or something of that sort, in which, of course, we are interested, too.

The thing that I am greatly concerned about is we have research going on in all fields. Don't you think there should be some cooperative effort to try and jell those things together so that we will not be all over the field?

Mr. McCone. Well, it is rather difficult to do that. These are areas of specialization. For the present time and for the foreseeable future, the AEC buys more coal than they replace, Doctor. We purchase 25 percent of the coal that is produced in the State of Kentucky for our plants, this through the TVA and through our own powerplants, so in some ways maybe we are the salvation of the coal industry.

Mr. Fenton. When you speak of coal you mean soft coal, bituminous coal.

Mr. McCone. Yes; that is the coal down there.

RESEARCH ON NEW USES FOR ANTHRACITE COAL

Mr. FENTON. Of course, there is a vast difference, as you know, between bituminous and anthracite.

That leads me to another thought, Mr. Chairman.

Anthracite, or hard coal, as you know, and I know something about this, hardens into what is known as black diamonds. Is there some use for black diamonds or could any use for anthracite coal be accommodated by your research in atomic development?

Mr. MCCONE. Not that I know of.

Maybe Dr. Williams could answer that more knowledgeably than I could.

Dr. WILLIAMS. Of course coals, as you know, are used as a source of many chemicals. That is a question, again, of economics for heating and for chemical use.

Ultimately we will tap all sources of coal, as the supply gets shorter and shorter for these chemical uses.

Mr. FENTON. I am glad I had something to do with establishing a research laboratory for anthracite coal. The only laboratory we have for research work is in my district and I was the author of the legislation in which, through cooperation with industry, we have developed new uses, not only for the coal itself, along the chemical line, but from slag and the refuse.

General Dynamics and Philadelphia Coal & Iron Co. have gotten together and they are going to plan, and I am very happy about this, in view of the depressed area I come from, I hope to establish a hundred million dollar plant for the very thing that Dr. Williams has talked about. They will utilize the refuse, not the coal itself, but old refuse that was thrown out years ago as waste on culm banks. Certainly we are now going to become competitive, I think, with "by-products" of bituminous coal. I thought probably the AEC might have thought of something like that; to find out whether or not you could do research work along that line, too, in your atomic energy program.

Would Dr. Williams care to comment on that?

Dr. WILLIAMS. Our program is basically oriented toward the atomic energy field and its ramifications. I would feel that this is an extremely important area of research you are talking about. It would seem to me a determination would be necessary by the Congress and certainly by the Commission to enlarge the scope of our interests.

Mr. FENTON. That is all, Mr. Chairman. Thank you.

PARTICIPATION OF PRIVATE INDUSTRY IN POWER REACTOR DEVELOPMENT

Mr. CANNON. Before we leave that subject, the original policy of the Commission seemed to have been to restrict participation in these programs to private industry.

The participation of the Government itself was deprecated and out of that arose some question as to the committee's attitude toward free enterprise.

This committee has in every way possible tried to encourage participation by private industry. We met two obstacles. The first was mentioned by the gentleman from Iowa, Mr. Jensen, this morning.

It was the danger of tremendous damage, a responsibility which private industry could not assume. But as Mr. Jensen indicated this morning, due to that one fact and the activity originated by this committee, Congress enacted a law under which we provided Government insurance. Private industry could not get insurance. No insurance company or combination of insurance companies in the United States could insure against the enormous damage which might result from a miscarriage of some of these nuclear activities. So in order to encourage the participation of private enterprise, at the instigation of this committee, Congress enacted a law under which the Government provides insurance.

That disposed of the first obstacle, and it shows unmistakably the attitude of this committee toward the participation of private industry in these programs.

The second was that success of the undertaking was problematical. Corporations could not invest the funds of their stockholders in long-time programs in which profits were uncertain or at best were long deferred. It was inevitable that the Government would have to furnish a large part of the capital required, because no private corporation, however successful, could ask its stockholders to wait for dividends which might never materialize or which at best would be years in accrument.

Accordingly, we have invited private industry to participate; we have cooperated with them; we have provided the capital; we have provided the insurance; and certainly any question as to the attitude of this committee toward private enterprise in developing atomic energy has been convincingly resolved. The record of the committee shows conclusively that we are doing everything we can to encourage the participation of private enterprise.

We encourage the investment of the Goverment funds in order to povide capital which would otherwise be wholly unattainable. At the same time we encourage the participation of cooperative enterprise to avoid the establishment of private monopoly.

Biology and Medicine

Mr. Cannon. We shall pass on to the biology and medicine program. You are requesting $49 million.

I shall ask the stenographer to insert here pages 154 through 182.

(The pages follow:)

Biology and Medicine Program—Operating Expenses

Program statement

Estimate fiscal year 1960	$49,000,000
Estimate fiscal year 1959	43,242,000
Increase	5,758,000

The Commission's program in biological and medical research and the accompanying budget estimates are developed and designed not only to maintain the high standards of health protection of atomic energy workers and the population as a whole in a constantly changing atomic energy scene, but to permit an energetic approach to the resolution of the many biomedical problems arising as a result of the developments of the atomic era.

The extensive testimony in the 1957 Joint Committee on Atomic Energy hearings on "The Nature of Radioactive Fallout and Its Effects on Man," the reports of the U.S. National Academy of Science and the United Kingdom Research Council on radiation effects, and the more recently published report of the United Nations Scientific Committee on the Effects of Atomic Radiation make clear the need for continued and expanded research on these problems affecting man of this or subsequent generations. The Joint Committee on Atomic Energy conducted a review of fallout hazards from nuclear weapons tests May 5–8, 1959, to update the 1957 hearings. These hearings in general served to reemphasize the need for resolution of problems highlighted during the earlier hearings. With the rapid advancement of reactor technology and the expanding medical and industrial uses of radioisotopes and other nuclear sources, as well as the utilization of nuclear devices to fulfill peaceful purposes, the need for a biomedical research program geared to the pace of these advances becomes imperative.

The budget contained herein provides for the continuation of essential research programs now underway and for the initiation or expansion of biodmedical research projects necessary to cope with presently recognized or potential radiation hazards of a biological or medical nature and special toxicity problems inherent in AEC operations. It reflects the planned growth of the research program in these areas placed in effect in fiscal year 1959, with a progressive development of these activities proposed for fiscal year 1960. The program will continue its balanced emphasis on useful peacetime applications, while recognizing the need for greater emphasis of research effort toward accelerating the resolution of problems of the biological hazards of radiation and those related to radioactive fallout. Major activities will include—

(1) Studies for predicting transport, deposition, and uptake of strontium 90, cesium 137, and other fission products through the cycle to the human body, as have been or may be produced by the detonation or transport accident of nuclear devices, reactor or production plant accident.

(2) The somatic effects of high- and low-level radiation, internal and external, on individuals, such effects including life shortening and carcinogenesis.

(3) The genetic effects of high- and low-level radiation on present and future generations.

(4) The effects of radiation on other biological and ecological systems which affect man's environment and his well-being.

The proposed biomedical research program for fiscal year 1960 will be carried out in 15 Commission-operated laboratories at an estimated cost of approximately $31,200,000, and through the support of over 500 research projects at over 200 universities, hospitals, and other research institutions at a cost of approximately $17,800,000.

Summary of estimate by category

Category	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
1. Radiation effects on biological systems	$11,956,683	$14,391,000	$16,089,000
2. Combating radiation detrimental effects	1,938,043	2,301,000	2,715,000
3. Beneficial applications of atomic energy	9,712,966	11,140,000	12,453,000
4. Biomedical problems in atomic energy operations	7,420,145	10,200,000	11,464,000
5. Dosimetry and instrumentation	1,984,213	2,498,000	2,767,000
6. Civil effects	725,220	892,000	1,500,000
7. Equipment not included in construction projects	1,600,800	1,820,000	2,012,000
Total biology and medicine program	35,338,070	43,242,000	49,000,000

JUSTIFICATION OF CATEGORIES

1. Radiation effects on biological systems, $16,089,000

(*a*) *Medical Research.*—Fiscal year 1958, $5,051,600; fiscal year 1959, $6,008,000 fiscal year 1960, $6,593,000.

The researches in this category are directed toward a better understanding of the effects of radiation on tissues of animals and man and a more precise estimate of the radiation hazard to the human population.

Studies on internal emitters, including strontium 90 and other radiosotopes, previously confined mostly to small laboratory animals, will be extended to include comprehensive long-term experiments on dogs and monkeys. These investigations are expected to demonstrate those concentrations of radio isotopes at which only negligible effects would be produced or at which the chances for grossly detectible effects would be statistically insignificant.

The study of the metabolism of the radioisotopes of various elements at very low dosage levels will be extended to human subjects. The development of controlled low-level counting facilities has provided a whole body radiation counter of such high sensitivity that the doses needed for complete studies in man will be well below the stated maximal permissible limits. The more immediate important isotopes such as strontium 85, cesium 137, and radium 226 are already under investigation using this and related instruments. These investigations will provide data for the study of the toxicity of natural radioactive materials in humans, for the refinement of figures used to compute permissible dosages for man in air, water, or foods, and for the prediction of changes which might be expected to occur in man as a result of exposure to radiation from radioisotopes which have been or are still present in the human body.

Increased attention will be given to experiments dealing with the gastrointestinal and nervous systems and the immunity mechanisms of the body. While it has been observed that sufficient radiation will "paralyze" the immune mechanisms of the body, these mechanisms in the radiation syndrome will be studied because of its sometimes decisive role in recovery. Various immunologic systems are under intensive study and will be correlated with studies of electrophoretic separations and other physical chemical means of identifying the components of these systems. The transplantation of tissues thought to provide immunity in relation to various types and doses of radiation in normal animals and chimaeras induced in utero may go far to answer the question of the specific identity of the immunity-producing cells. Extensions of this work may lead to data on the role of immunity against tumor implantation and development of a means of directing radioactively labeled antibodies to a specific tumor or abnormal tissue so that highly precise localization of radiation may be achieved. Other studies in animals are designed to evaluate the degree of failure of immunity which might be expected in man to result from various doses of radiation accumulated at different rates and in differing time patterns.

The nervous system will be investigated from the standpoints of the pathology to be found from relatively localized doses of radiation; the local effects produced by invivo capture reactions and by 900 million electron volt alphas and other particles of higher mass; the physiologic changes which may be found in the brain by means of indwelling electroencephalographic electrodes; and the effects in the peripheral nerves and ganglia by use of sophisticated neuropharmacologic techniques. The nervous control of the intestine will come under special study relative to its role in the motility of the intestine damaged by radiation.

The ability of the irradiated intestine to absorb certain test compounds such as vitamins and isotopically labeled amino acids and sugars will be investigated. Other studies are designed to provide further understanding of the mechanisms of deaths in animals occurring within 5 to 7 days after irradiation.

Major effort will be directed toward the study of the failure of the bone marrow, as a result of irradiation, which is responsible for the more delayed type of death. In addition to the effects induced by inhaled or absorbed radioisotopes such as strontium 90 and radium 226 which have been deposited in the matrix and crystals of the bone, the special effects of neutrons and other penetrating radiations are being examined. These investigations range from the tedious counting of the numbers of bilobed lymphocytes in the circulating blood of laboratory workers and uranium miners to the use of the bone marrow as the end point for determining the relative bilogic effectiveness of various types of ionizing radiation. In the former experiments the bilobed lymphocyte may offer the best working index for the evaluation of radiation doses at levels of 1 to 2r, but the relation of this "bilobe phenomenon" to other forms of stress and disease must be established. An electronic device to detect and compute the number of such bilobed lymphocytes will be used to explore this field thoroughly. Further, experiments on the marrow and peripheral blood in radiation sickness will provide additional information required to make practical use of the demonstration that homologous grafting of bone marrow is feasible. Thus the blood platelets will continue to

be studied from the standpoints of origin, composition, function, and preservation in the irradiated animal and the locally irradiated human. Similarly, the effects of radiation will be examined with reference to the production of plasma proteins, the utilization of amino acids, the lipids of the liver in adults and embryos, the glycoproteins, mucoproteins and collagen, nucleic acid synthesis in a variety of life forms, the lipoproteins of cell membranes, and various types of cells growing in tissue culture.

Each of these studies will contribute data fitting into the basic pattern needed for the understanding of the biochemical and biophysical phenomena of the radiation syndrome.

The late, delayed, or chronic effects of previous exposure to radiation will be studied chiefly from the standpoint of the amount and timing of radiation needed to induce the now well-recognized carcinogenesis, nephrosclerosis with hypertension, cataract formation, and the accelerated aging with early death generally expressed as shortened lifespan. Since chronic effects are being studied, the experiments must have continuity in time and be correlated with investigations of related phenomena such as the epidemiology of natural aging and the effects of background radiation. The unified study program of the Atomic Bomb Casualty Commission in Japan will continue to follow the exposed and control populations of Nagasaki and Hiroshima for securing the maximum utilizable data on the chronic effect of radiation on man.

As knowledge of the cosmic radiation of space increases, laboratories which have very high energy accelerators (Lawrence Radiation Laboratory, Brookhaven National Laboratory, and Yale) will undertake investigations in this branch of radiation biology. The possibility that particles of heavy mass existing in the upper levels of the earth's atmosphere may result in a different kind of damage to biological systems than those studied up to the present will be investigated. The Lawrence Radiation Laboratory has begun a biologic research program hinged around the several high-energy machines available at the Lawrence Radiation Laboratory complex.

(*b*) *Biological research.*—Fiscal year 1958, $6,016,335; budget year 1959, $7,476,000; fiscal year 1960, $8,517,000.

Basic radiation biology studies will be continued and expanded. Only by understanding the effects of radiation on viruses, enzymes, and other large molecules can we understand the effects of radiation on cells, tissues, and, ultimately, on the entire body. Knowledge of the mechanisms underlying the fundamental radiobiological effects may suggest avenues of investigation to be followed in the search for means to alleviate or prevent radiation damage.

One of the major objectives under this category is the obtaining of critical genetic information on which to base more accurate estimates of the genetic hazards of radiation to human populations. The need for additional information has been reiterated by the report of the United Nations scientific subcommittee on the biological effects of radiation. The establishment of sound permissible exposures of individuals and especially of populations requires reliable estimates of the human genetic hazards. In particular, much more information is needed on human mutational loads as estimated by studies of the offspring of consanguineous marriages and an mammalian mutation rates at low chronic exposure levels.

The National Academy of Science Report of 1956 estimated that only about 10 percent of the total genetic damage of simple genetic origin is expressed in the first-generation offspring of irradiated parents. The evaluation of these immediate effects, though far from precise, is considerably simpler than the evaluation of the more persistent long-term effects of more complex genetic origin. The effect of radiation on the first-generation offspring of exposed parents may provide the most valuable single criterion of genetic damage cause by radiation. These data, first obtained in studies at the Oak Ridge National Laboratory on offspring from neutron-irradiated mature sperm in mice surviving the test Operation Greenhouse, will be extended to include studies of X-radiation of spermatological stages. Studies of the effect of radiation on the longevity of the first-generation offspring may provide an accurate method of comparing effects in different animal species and hence render the eventual extrapolation to man more reliable. Extension of such studies in swine to be initiated in fiscal year 1959, are contemplated in fiscal year 1960.

Longevity is only one of a number of so-called polygenic or quantitative characters influenced by many genes. Intelligence, general health and well-being, and

fertility are other examples. Studies of the effects of radiation on polygenic traits in both animals and plants will be expanded.

Investigations of the variations in radiation-induced and spontaneous mutation rates in different species, at different stages of development, and under different physiological conditions will be continued. Laboratory plants and animals are used in this work, and the studies with mice at the Oak Ridge National Laboratory are especially valuable. Studies of the effect of chronic low-level exposures in mice suggest that the effects on fertility may be greater than expected whereas the mutation rates observed in preliminary tests appear somewhat lower than predicted on the basis of a linear mutation-dose relationship.

The feasibility of a study of the offspring of patients receiving large doses of therapeutic radiation is currently being examined. Cytogenetic and mutational studies of human cells in tissue cultures will continue to be encouraged with emphasis on procedures or techniques to keep the cells in the normal diploid state. The successful solution of this technical problem is important to future tissue culture studies.

Studies of the offspring of consanguineous marriages yield information on the mutational load of human populations, on the spontaneous or background mutation rates, and on the genetic structure of human populations. Such studies will be expanded in the United States and will be compared to further studies of populations in Japan and Italy, in which the rates of consanguineous marriages are significantly higher than in the United States.

Studies are to be expanded on the effect of patterns of mating, that is, differing degrees of consanguinity, on the persistence of genes in experimental populations. Associated with this is the problem of the variable expression of a mutant gene in the heterozygous state and the effect this may have on the rate of gene elimination. Such work is readily done in Drosophila populations but it is planned to extend certain crtical tests into mammalian systems, as mice and rats.

Another major objective of the genetics research program is the elucidation of the detailed chemical and structural nature of the genetic material and the precise manner in which these are changed by radiation. A complete understanding of these phenomena holds forth some hope that the damaging effects of radiation might be partially ameliorated. Molecular level genetic studies in viruses and micro-organisms will be expanded. Feasibility of studies of the genetic effect of carbon 14 decay to nitrogen 14 and of phosphorus 32 decay is now being considered. Suitable laboratory plant and animal species will be used in studies of mutation phenomena at low doses and under chronic or fractionated exposures.

(*c*) *Biophysics research.*—Fiscal year 1958, $590,473; fiscal year 1959, $413,000; fiscal year 1960, $413,000.

Radiation biology is devoted to studying the mechanisms by which ionizing radiation affect biological systems. The ionizing radiations cause immediate chemical changes within the cells of the organism but the events between these initial changes and the biological effects which result are extremely complex and little understood and will be the subject of continuing research. The use of synchronously dividing cells will provide a more uniform background against which to study the biochemical changes which result from irradiation damage and, in addition, will give information about the stages in cellular division most susceptible to radiation. An understanding of the chemistry of these radiation-induced changes at the cellular and subcellular level can be gained only after the broad parameters of dosage, time of irradiation, and such other factors have been defined.

The following broad types of research in biophysics will be continued in fiscal year 1960:

(1) The development of devices and radiation sources of all types in order to study radiation effects from any type of radiation likely to be encountered by living organisms as a result of natural radioactivity, cosmic radiation and radiation arising from power reactor operations and atomic explosions.

(2) Improvement of means for evaluating the absorption and transfer of radiation energy in biological systems and for expressing damage to the organism or cell in a more precise and meaningful manner. In particular, the use of paramagnetic resonance and other related techniques to measure the initial chemical products formed by absorption of radiation by living cells will be investigated.

(3) Location of a biological system in animals which shows an immediate and measureable response to low levels of radiation. Such a system is important as a means of quickly diagnosing the dose of radiation received by an individual in order that the proper type of therapy may be started.

(4) Evaluation of primary radiation damage to living organisms from radiations of different energies and studies on the irradiation of different-sized chemical molecules.

(*d*) *Environmental sciences.*—Fiscal year 1958, $298,275; fiscal year 1959, $494,000; fiscal year 1960, $566,000.

Research projects in this category are designed to provide scientific knowledge of environmental conditions in natural habitats prior to the advent of intensified radiation in order (1) to establish a baseline for evaluating increased radiation and (2) to isolate from other environmental factors the effects of radiation on biological systems involving whole populations of plants and animals. The determination of the nature of biological systems prior to the establishment of radiation as a factor in the environment and of the characteristics of the distribution of radioactive materials from Commission operations must be achieved before the ecological effects can be approached or distinguished from radiation effects.

To this end natural conditions as they prevail in segments of major soils, vegetational, and climatic regions are being mapped. Radiation background will also be measured.

Projects planned for continuation in fiscal year 1960 include mapping and restudy of certain local fallout patterns of the past decade: mapping and study of vegetation and its succession in denuded areas; study of natural populations (algae, seed plants, arthropods, mammals, birds) in prospective reactor sites; bioclimatic studies; natural productivities (photosynthesis potential) in land, fresh water and marine habitats.

It is anticipated that the researches on total ecology of Rongelap Atoll, begun in late 1957, will be expanded. Here contamination has already occurred and the atoll represents one of the unique areas in the world with reference to artificial radiation; and the effects on plants and animals are now in process of measurement. In addition radioactive isotopes provide tracers for the study of minerals in the environment on a scale impossible to duplicate under practical experimental conditions. The study there is of interest also because the natives, with their return, have become an integral part of the ecological system.

Since conditions previous to heavy contamination in 1954 can be reliably estimated, calculations of half-life and rate of decline can be simplified and effects of different levels of contamination will be observed by sampling at various islands.

2. *Combating radiation detrimental effects, $2,715,000*

(*a*) *Medical research.*—Fiscal year 1958, $1,110,898; fiscal year 1959, $1,234,000; fiscal year 1960, $1,468,000.

The problems of combating the detrimental effects of ionizing radiation are determined by the amount and source of the radiation. It has been demonstrated in radiation environments closely approximating those which could result from detonation of nuclear weapons or accidents in industrial processing of nuclear materials, that small animals can be protected from the effects of lethal doses of external gamma and neutron irradiation. The organic chemical compound, S,2–aminoethylisothiuronium. Br–HBr, if given immediately before radiation exposure, and bone marrow cells, if given after exposure, will protect 100 percent of a group of mice exposed to an otherwise lethal dose of X or gamma radiation. Recent tests of AET have shown that it is much too toxic for effective use in dogs, monkeys, and man. Work now in progress indicates that (1) the method of administration of AET may be modified to reduce the toxicity, and (2) other chemical compounds closely related to AET may be equally effective, but less toxic, in larger species. These studies will be continued.

Further investigation of bone marrow therapy to radiation injury in man will be undertaken. A considerable number of patients with incurable cancer and anemia have received bone marrow infusions with no detrimental results. However, attempts to treat leukemia by irradiating the entire body of the patient with X- or gamma-rays in the hope of destroying the diseased bone marrow and then replacing it with healthy transfused marrow have thus far been unsuccessful. Studies to provide information on the radiosensitivity of

human bone marrow, facilities for delivery of a uniform and accurately measured radiation does to the human body, and the immunological reactions of transplanted marrow in the human host will be expanded in an effort to resolve the problems of bone marrow therapy.

Investigations of the protective and therapeutic value of cellular material other than viable bone marrow, liver and spleen cells will continue in an effort to determine whether there is experimental evidence that any cellular extract or blood fraction has a pronounced effect in reducing the mortality of lethally irradiated animals.

The other major source of damaging radiation to the human body, internal emitters, is of interest from the industrial standpoint. Accidental ingestion and inhalation of radioactive materials occurs in nuclear manufacturing and processing operations. Other radiation incidents may on rare occasions become a hazard to the general population. Accurate and rapid estimation of radioactivity retained by the body is necessary for proper handling of the patient. Methods for increasing the excretion of the retained isotope are now available for some elements. There is, however, no efficient method for decreasing the body burden of many of the bone-seeking elements, such as strontium 90. Investigation of chelating agents for this purpose will continue. Studies on physiological and humoral factors affecting the metabolism of various mineral elements may eventually lead to more useful methods of decontamination, and will be expanded in the next few years.

The delayed effects of sublethal doses of radiation as well as effects caused by long exposure to low levels of radiation, are receiving increased attention. Projects for the study of radiation mortality will be extended to determine if the treatment which protected against acute radiation injury and death may also modify or delay the appearance of the late effects, such as life shortening and carcinogenesis. These studies will be expanded as additional animal-holding facilities become available.

(*b*) *Biological research.*—Fiscal year 1958, $734,373; fiscal year 1959, $989,000; fiscal year 1960, $1,168,000.

Observation of the temporary recovery of living organisms from acute radiation point up the fact that considerably more emphasis should be placed on this area of research. In particular, a comparison of the effects of fractionated doses to an acute dose of equivalent total energy needs thorough investigation. Research in the following areas will be emphasized:

(1) Immunological responses of irradiated animals and tissues.

(2) Metabolic or structural changes in the cell resulting from radiation exposure of high and low levels and of different kinds of radiation.

(3) Means of reducing the absorption and deposition of internally ingested radioactive isotopes or of removing them once they are in the body.

(4) Nontoxic synthetic or naturally occurring compounds which will counteract the ill effects of radiation.

(5) Total body irradiation of large animals, including the mechanism of damage, ways in which recovery can be accelerated, and ways in which damage can be counteracted.

(6) Effects of radiation on fertility and reproduction, including the relative effect of fractionated doses and an acute dose of the same total energy. This factor might be more significant than the genetic effects of radiation in the immediate survival of a chronically irradiated population.

The increased emphasis being placed on research and power reactor programs points up the urgent need for more fundamental information about the uptake of natural and induced radioactive elements by plants and subsequently by animal and human populations. Studies planned with animals grown in a radioecology, both natural and induced, will give much information concerning the radiation hazards of these facilities. The effects of radiation on the production of anemias, thrombocytopenias, and other diseases will be studied at the cellular level in order that better methods of treatment can be devised for countering these harmful effects of radiation.

Additional emphasis will be placed on an evaluation of the deleterious effects caused by the rupture of chemical bonds in biologically important molecules following transmutation of certain radioactive chemical elements, such as carbon or phosphorus.

(*c*) *Biophysics research.*—Fiscal year, 1958, $92,772; fiscal year 1959, $78,000; fiscal year 1960, $79,000.

Biophysical research develops the tools with which the biological effects of radiation are studied, and will be applied to the solution of problems arising in

many phases of nuclear energy operations in which exposure of personnel to radiation must be limited or in which the detrimental effects of radiation must be reduced and which have been intensified by the increased use of high energy radiation sources. The Lawrence Radiation Laboratory will continue to investigate radiation hazards, the establishment of safe standards, and the development of appropriate shielding and other measures for new facilities and experiments.

3. Beneficial applications of atomic energy, $12,453,000

(*a*) *Cancer research.*—Fiscal year 1958, $3,503,764; fiscal year 1959, $4,172,000; fiscal year 1960, $4,510,000.

The completion of a number of research and radiotherapeutic facilities in fiscal year 1959 has provided the basis for expanded investigations in this category. Radiotherapeutic studies at Oak Ridge Institute of Nuclear Studies will expand with the delivery of two new designs of teletherapy units. The 65-Mev. linear accelerator at the Argonne Cancer Research Hospital and the medical research reactor at Brookhaven National Laboratory will be operating at full scale during fiscal year 1960. The 184-inch cyclotron at Lawrence Radiation Laboratory is being utilized for studies of the treatment of pituitary neoplasms and other deep-seated, well-localized cancers. The teletherapy-van de Graff equipment at Argonne Cancer Research Hospital is equipped with a new cobalt source which makes it the highest specific activity source in use on human subjects.

Research will be continued to define the usefulness of various brachytherapy devices in such areas as the implantation of strontium 90 seeds in pituitary tumors and the thread insertion of liquid isotopes in tumors of the head of the pancreas. Efforts directed toward the preparation and utility of radiocolloids such as $Lu_2{}^{177}O_3$ and $Cr^{51}P^{32}O_4$ will continue.

Coincident with the development of improved techniques for administering stipulated amounts of whole-body radiation, there will be studies of the combined administration of whole-body radiation followed by supportive bone-marrow transplants for the treatment of leukemias. Information resulting from such studies will be applied to determining if it is possible to graft actively reproducing cells from man to man.

Supporting these clinical applications will be studies directed toward the localization of tumors beneath the surface of the body by means of special external detecting devices and the technical refinements which will make the methods into reliable diagnostic aids. Isotopes being used for this purpose are phosphorus[32], manganese[54], and iodine[131] as the ion and as a label on certain organic carrier atoms. In addition to the elementary stationary detectors, new and improved types of mobile and "area" scanning devices will be developed and used.

Additional radioactive isotopes in various pharmacological forms which have not received much attention by biochemists and toxicologists up to now will be studied for possible utility in treating various types of cancer. Normally, the sequence in studying such elements is physical-chemistry to animal experiments to toxicology to clinical trial. The general level of activity in this field will remain at about the same level as fiscal year 1959.

Research and clinical studies of the use of the hematopoietic substance "Erythropoietin" in relatively pure form in various neoplastic and related diseases will continue to be supported in fiscal year 1960. The utility of such a substance for red cell formation will be investigated as a possibility for the treatment of many blood conditions and diseases in which blood formation lags or has been suppressed, as in radiation sickness.

Biochemical studies of the metabolism of various hormones having a relation to the development and spread of cancerous cells will be continued at approximately the level of the previous year. Such studies depend on the availability of suitable patients and are pursued by means of the long-term single-case technique The synthesis and purification of suitable hormones labeled with sulfur 35, carbon 14, tritium, iodine 131 and/or phosphorus 32 as a necessary preliminary step will be undertaken.

Similar labeling techniques will be employed to increase the pace of research in the field of immunologic treatment for cancer. This work is largely in the fundamental stages of studying the conditions under which the antigen-antibody reaction occurs with the ultimate aim of being able to prepare and direct a lethal antibody specifically against the tumor tissue. This cytotoxic reaction against bacteria invading the body is relatively simple because the proteins of the bacterium are quite foreign to the body of the animal. In the case of human and animal tumors, however, the differences between tumor and normal

tissue are less definite and it is difficult to exclude normal tissue from the antigenic preparations. The coupling of radioisotopes and fluorescent materials to antigen and/or antibody will be studied to determine whether ultimately such an immunologic treatment for cancer is feasible.

Other substances under intensive study are desoxyribonucleic acid and ribonucleic acid, which when combined with specific proteins represent the genetic identity of a cell. While fundamental to many fields of biology, this genetic material in cancer cells will receive special study as it presents an opportunity to correlate certain biochemical abnormalities of its composition with the special characteristics which label a cell as "cancerous." Radiation in certain doses is able to induce such changes, while higher doses will induce additional changes sufficient to destroy the cell. Using these facts, investigations are vigorously being pursued on the interrelations of radiation and the nucleic acids.

(*b*) *Medical research.*—Fiscal year 1958, $2,683,986; fiscal year 1959, $2,714,000; fiscal year 1960, $3,013,000.

Investigations of the use of radioactivity labeled compounds to study the biochemistry and biophysics of normal and disease processes in man and experimental animals will be continued and expanded. For example, the metabolism of vitamin B_{12} labeled with cobalt 58 or cobalt 60 will be studied in a variety of blood diseases and anemias to identify more specifically the biologic function of B_{12} as well as to investigate the disease processes themselves and their therapy.

The metabolic turnover of hexose and pentose sugars as influenced by the glycotrophic fraction of the adrenocortical hormones is being investigated in man by use of carbon 14 and tritium. Such experiments in man are difficult to interpret, however, because these carbohydrates quickly become incorporated into a series of cyclic metabolic chains which contribute to the composition of the blood sugar pool; this pool is rigorously controlled by a complex of homeostatic mechanisms? Consequently, the above type of experiment on man will be supplemented and complemented by studies on experimental animals under controlled conditions.

For example, the application of the perfusion technique to the livers of experimental animals will be studied in order to analyze the contribution of the liver to the maintenance of the blood sugar pool. Experiments such as this are expected eventually to provide the basic data which will be the key to understanding abnormalities created by diseases.

Experiments on diseases will be continued since they represent a readymade experimental situation. Thus, carbohydrate metabolism in the diabetic human and experimental animal will continue to be the subject of close experimental study. Carbohydrate metabolism is closely related to protein and fat metabolism in a number of tissues and is controlled both by the nervous and endocrine systems, and the present analytical investigations will provide data which will lead to more critical experiments in the future. This field is under intensive investigation, and it is expected that the use of radioisotopes will lead to success where the conventional biochemical and endocrinological approaches failed in the past.

Similarly, Carbon^{14} labeled fatty acids and cholesterol are being administered to animals to study the development of the lipoid materials found in the arterial plaques characteristics of atherosclerosis. The physical-chemical characterization of these fatty macromolecules will be studied in their relation to other metabolic diseases and the possible chronic effects on lipoprotein metabolism produced by irradiation.

The utility and value of fresh whole blood, blood platelet preparations, and lyophilized platelets for the treatment of blood diseases in which bleeding occurs has been under investigation in various clinical diseases for several years. These studies will be continued and expanded by using more recently improved labeling techniques for platelets which now makes it possible to follow directly the survival of transfused platelets in the host and preserving container. This will be the subject of research for several years just as the iron^{59} labeling technique for hemoglobin continues to be the foundation for studies on red blood cell formation in many diseases and under varied physiologic conditions.

One component of the blood platelets, 5-hydroxytryptamine, will be given special study since it may prove to have a function in controlling the normal vasomotor tone of the blood vessels. The metabolism of this substance and its excretory product, 5-hydroxyindole acetic acid, will be examined thoroughly in various blood conditions.

Studies of movement of radioactive ions and labeled compounds throughout the body into and out of various fluid compartments and cell masses, coincident with improved mathematical analyses of the sequences of changes, will deal with the dynamics of mixing of fluids in the circulatory system, estimates of regional blood flow, the measurement of cardiac output, the determination of gross and fat-free body mass, and estimates of physiological age based on rates of turnover of vital components such as the sodium, potassium, calcium, and/or magnesium reservoirs and depots of the body. Similarly, measurement of the ability of the tissues to use labeled amino acids for the manufacture of proteins, the catabolism of such proteins, and their reuse will be continued and may also serve as indexes of physiologic fitness.

Other elements whose metabolism is less well understood will be investigated for their relation to abnormal states and disease. There are manganese, copper, phosphorus, cobalt, strontium, yttrium, iodine, radium, cesium, astatine, zinc, lanthanum, calcium, and magnesium. The practical application of such studies is not fully defined, but copper, for example, seems to bear a relation to hepatolenticular degeneration, a relatively uncommon but fatal disease of the central nervous system and liver.

The value of *Drosophila melanogaster* for a variety of radiobiological procedures and tests other than genetic analyses has now been demonstrated. For example, this fruitfly has been grown for five generations on a brewer's yeast broth which had been irradiated with 10^6 roentgen doses, demonstrating thereby that such foods are not made toxic or unfit for nutrition. Additional uses for this insect in radiobiology will be the subject of further investigation.

Another recent advance which will be developed and exploited is the demonstration that radiation of proteins in solution will induce the formation of the very reactive carbonyl grouping on the protein molecule by reaction with the hydroxyl-free radical produced by radiolysis of water. Studies are planned to demonstrate that the carbonyl also forms in vivo, to identify the sites of formation, and to describe the chemical configurations needed for the reaction.

(c) *Biological research.*—Fiscal year 1958, $2,983,449; fiscal year 1959, $3,430,000; fiscal year 1960, $3,988,000.

The biological research projects are expected to uncover new fundamental facts concerning the cellular physiology of man, various animals, plants, and micro-organisms as these new facts relate to improved food production, food preservation, and the general health of the population. Through the use of radioactive isotopes, it has been possible to trace the pathway of water and various ions through the soil into plants and finally into animals and man. Continued studies with this powerful tool—the radioactive isotope—are essential to a better understanding of the basic biochemical reactions which control growth and repair damage, and thus lead to an elucidation of the nature of radiation injury.

The research in this field will continue at an increased level in fiscal year 1960 and will include the following:

(1) There are many applications of atomic energy which are of potential value to agriculture and industry. The role of the Commission is to explore the feasibility of such applications in pilot studies with the responsibility for actual application resting with other agencies. This has essentially been done in the case of induced mutations in plant breeding. Radioisotopes have been adopted to a limited degree in studying the metabolism of invertebrates, particularly insects and various parasitic forms. The use of the radioisotopic tool should be expanded and more pioneering studies on the feasibility of using atomic energy to control various pests and diseases will be initiated.

(2) Studies of the biochemical synthesis of proteins, carbohydrates, fats, vitamins, various hormones, and growth substances, and the mechanism of how enzymes do their biological work and how they are affected by radiations, through the use of radioactive isotopes will be continued. Alteration of nucleic acids is thought to be involved in the primary radiation damage to genetic material and other cellular components. Investigations on the structure, function, and metabolism of the nucleic acids are needed to understand better their function in cellular metabolism.

(3) Mineral metabolism in plants, animals, and micro-organisms, particularly their uptake, movement across cellular barriers, and metabolic roles.

(4) Preliminary evidence indicates that primary tissue damage by ionizing radiations can be reversed by subsequent exposure to visible light. Studies are needed to reveal the biochemical reactions affected by visible light.

(*d*) *Environmental sciences.*—Fiscal year 1958, $288,299; fiscal year 1959, $514,000; fiscal year 1960, $542,000.

Ecological research related to the beneficial applications of atomic energy will be continued in fiscal year 1960 and will include the measurement of biological productivity in oceans, lakes, and streams, and mineral metabolism experiments to determine the elements that are essential to biological production in an acquatic environment.

The carbon 14 method, a technique used by hydrobiologists to measure food production of one-celled plants through photosynthesis, will receive further study. On this information can be based estimates of total food production of a lake, stream, or portion of an ocean and its capability to support associated aquatic and terrestrial animal populations.

The productivity of a body of water usually can be increased by adding fertilizers at random, but these methods of fertilization are wasteful and may result in the production of an undesirable species. By the use of radioisotopes the important minerals for maximum production of desirable species can be determined. Also fertilizers which may be lost to the cycle of biological production by adsorption to silts or mud or by forming an insoluble compound can be traced with radioisotopes and in this way the condition that needs to be remedied can be identified. Studies of all of these problems will be continued in fiscal year 1960.

(*c*) *Distribution of radioisotopes under research support program.*—Fiscal year 1958, $253,468; fiscal year 1959, $310,000; fiscal year 1960, $400,000.

This program continues to be an important adjunct to the total "Biology and medicine research" effort as it relates to the use of radioisotopes in basic research investigation in the life sciences.

The support program recently completed its third year of providing radioisotopes at a reduction of 80 percent of cost for research uses in the fields of medicine, biology, and agriculture. An overall increase of 16 percent in purchase volume was experienced in fiscal year 1958, and current interest in the support program provides firm indication that the level of support proposed for fiscal year 1960 is commensurate with increasing research activities utilizing radioactive isotopes. The recent general availability of magnesium 28 for medical research will of itself contribute a significant increase in fiscal year 1960 above the previous growth rate of the program. Magnesium 28 is the only isotope of magnesium currently available for human electrolyte studes and, as such, its use will continue to rise during the next several years.

The fields of research represented in the following tabulation including medicine, microbiology, biology, biochemistry, agronomy, plant pathology, plant physiology, and pharmacology.

The total number of discount purchase certificates currently in use is 223. The distribution of these certificates among the various types of institutions is as follows:

Type of institution and number of certificates

(1) Colleges and universities	115
(2) Hospitals and medical centers	53
(3) Other nonprofit institutions	35
(4) Profit institutions	20
Total	223

4. Biomedical problems in atomic energy operations, $11,464,000

(*a*) *Medical research.*—Fiscal year 1958, $1,143,045; fiscal year 1959, $2,312,000; fiscal year 1960, $2,722,000.

In addition to the hazards from radiation exposure, the atomic energy industry is confronted with several other real and potential hazards. The mining, milling, and concentration of radioactive ores, and the purification, fabrication, and reprocessing of nuclear fuels result in hazards, which will receive continuing investigation in fiscal year 1960. Studies will be expanded on problems of contamination in industrial environments which might result from other Commission operations. The requirements of power reactor engineers for structural materials able to withstand high temperatures and pressures in intense radiation fields for long periods of time without corrosion or other metallurgical damage have resulted in the commercial production of many chemical elements once considered laboratory curiosities. These include such elements is indium, zirconium, thallium, niobium, and europium, together with various alloys. Studies

will be continued to screen various forms and compounds of these elements for acute and chronic toxicity before large-scale production and fabrication is started in Commission or contractor facilities. Much of this work is concentrated at the University of Rochester atomic energy project. Investigation of problems have been developed and will be expanded in off-site laboratories, and a systematic study of the inhalation toxicity of the rare-earth elements, including cerium, lanthanum, neodymium, and praesodymium, will be continued in fiscal year 1960. A number of unique toxicological problems relating to a specific industrial or weapons program will receive short-term intensive investigations to obtain recommendations for continuing the operation most efficiently and safely.

Examples of the program, including those expected to increase in scope and activity in fiscal year 1960, are—

(1) A comparative study of the inhalation toxicity of the rare-earth compounds in relation to the separation and metallurgy of these elements, after completion of the study of oral and parenteral toxicity.

(2) A continuing study of the effect on the lungs and other organs of inhaled radioactive and nonradioactive particulates, particularly in relation to the possible production of lung cancer. The radiation dosage and other parameters required to produce lung tumors will receive increased attention using newly developed laboratory techniques. Collaboration with the U.S. Public Health Service in the study of uranium miners and their working environment will continue. It is planned that a low-level counting facility, at the Colorado State Health Department will be used in the study of the miners. Several additonal low-level facilities will be established at selected medical research centers and will be available for the investigation of industrial medical problems.

(3) The inhalation, retention, and metabolism of mixed fission products that may be released as the result of certain types of reactor failure will receive increasing attention. A new program, in collaboration with the Division of Reactor Development, will be underway in fiscal year 1960.

(4) Chronic beryllium and mercury exposures continue to present problems that may take many years to resolve completely, and will be studied at present levels of support in fiscal year 1960.

(5) Work on the toxicity of thallium and indium and studies of the long-term exposure of animals to uranium oxide dust will be continued and should be completed by the end of fiscal year 1960.

(*b*) *Biological research.*—Fiscal year 1958, $2,254,302; fiscal year 1959, $2,209,000; fiscal year 1960, $2,430,000.

Research in this program is directed toward revealing the reactions in plant and animal systems of various fission products arising from atomic energy operations and of particular importance with relation to increasing development of reactor power installations. These studies will be continued both in controlled laboratory conditions and in the field to evaluate more precisely the way in which these products enter the food chain and are eventually ingested by man. This two-pronged attack affords an understanding of how environmental factors such as moisture, temperature, light conditions, and the presence of other mineral nutrients may alter the uptake. In the past greatest emphasis has been placed on strontium and cesium uptake; future studies will be expanded to include other elements to provide a well-rounded picture of total fission products distribution and potential hazard. Continued interest will be placed on relative accumulation of the different fission products by different plant and animal species. Methods of decontaminating agricultural lands made useless by fallout or reactor discharge will be studied. In particular, studies of physical and chemical treatments of soils for the reduction of the availability of fission products to plants, and studies of natural and cultivated plants which might be utilized to reduce food contamination or to decontaminate soil will be continued and expanded.

(*c*) *Biophysics Research.*—Fiscal year 1958, $2,385,653; fiscal year 1959, $1,293,000; fiscal year 1960, $1,314,000.

This category is concerned largely with studies of the biological significance of radioactive substances and toxic chemicals which are released to the environment by normal operations of Atomic Energy Commission installations, and which may be expected to be released in even greater amounts as powerplants and other industrial uses of atomic energy increase in number. The physical, chemical, and biochemical behavior of these elements after release to the air,

water, and soil of the environment determines their degree of hazard to the biosphere, and will be the subject of expanded research in fiscal year 1960. This behavior is closely related to such environmental factors as soil chemistry, geological structure, topography, hydrology, meteorology, and the nature of the plant and animal life. Studies in this category are of special importance in the Hanford area, as they affect the Wahluke slope and the Columbia River, and also in the Oak Ridge and Savannah River areas, and will be of particular application wherever the installation of large reactors is contemplated.

Other studies will deal with the manner in which radiation delivers energy to living cells, and its measurement. The action of mixed radiations is a continuing problem which will receive further attention particularly at Oak Ridge, Hanford, and the Lawrence Radiation Laboratory.

Research is continuing at the Health and Safety Laboratory on problems of industrial and mine dusts and ventilation, and detection of toxic vapors. Additionally, the Health and Safety Laboratory provides consultation and services in radiation control and industrial hygiene problems upon request to all divisions and offices of the Atomic Energy Commission.

(*d*) *Environmental science.*—Fiscal year 1958, $1,637,145; fiscal year 1959, $4,386,000; fiscal year 1960, $4,998,000.

Major objectives of the environmental sciences program are: (1) to determine the nature of biological environments prior to the establishment of radiation as an intensified factor in land, fresh water, marine, and atmospheric regimens; (2) to determine the distribution, concentrations, persistence, and rates of redistribution of radioactive materials from reactor operation, fuel fabrication and reprocessing, disposal of radioactive byproducts, peaceful uses of atomic power, and possible "accidents"; (3) to assess the biological effects (genetic and physiological) of radiation on communities of plants and animals in various environmental patterns (tundra, forest, desert, grassland, marine and fresh water, as well as domesticated situations such as pasture, cropland, aquatic agriculture); (4) to relate these effects to man and his health, welfare, culture, and industry, both agricultural and technical, through food and food chains, mineral cycles, erosion, and weather phenomena.

These objectives will be approached by simultaneous onsite ecological studies and offsite researches involving multiple facets of the environment—atmosphere, soil, topography, water, plants, animals, and conditions brought about by interrelations of these phenomena and biological systems, including studies of contaminated areas with special emphasis on objectives 3 and 4 (above).

Contamination with radioisotopes of any one part of the ocean becomes a possible source of contamination of the entire ocean. Therefore, research on circulation in deep ocean waters and the role of plankton in transporting isotopes will be continued with the objectives of determining the fate of radioisotopes introduced into ocean waters. The collections and analysis of biological samples and sea water from the central and western Pacific will be continued.

The program of worldwide monitoring of the land, air, sea, and food chains will continue. The resulting analytical data on the distribution of strontium 90 and other long- and short-lived bomb products and their changes with time will be correlated with known weapons tests and other releases of radioactivity and with data on the associated meteorological conditions. There will be a shift of effort to effects of radiation on biomass and biotic populations in the field.

Through joint efforts with other agencies, the movements and physical processes of the atmosphere will be studied directly and by means of tracers such as ozone, water vapor, and naturally occurring radioactive isotopes. Field and laboratory studies of the scavenging of suspended dust particles by rain, natural surfaces, and other collectors will also continue. These studies will provide an increasingly sound scientific framework for interpretation of the observed variations of radioactivity, for designing improved sampling programs, and for predicting the worldwide contamination resulting from past or hypothetical nuclear detonation patterns.

Stratospheric particulate collection by several different techniques being developed during fiscal year 1959 will be compared and evaluated. Based on the studies of sampling data, meteorology, sampling equipment performance, and information on the relative advantages of various sampling vehicles such as balloons and aircraft, a stratospheric sampling program will be developed during fiscal year 1960 to meet the long-term needs for such data insofar as these needs can be recognized at that time.

Micrometeorological studies designed to correlate wind, vertical temperature structure, and turbulence in the layer near the ground with concentrations

of plant effluents or test aerosols downwind of known sources will continue at a somewhat increased level in fiscal year 1960. These will provide data to improve the predictions, for site planning and hazards evaluation purposes, of onsite and offsite atmospheric contamination levels resulting from the peaceful uses of atomic energy, and to develop improved capability for guidance of emergency action, monitoring, and remedial measures in the event of inadvertent releases of radioactivity to the atmosphere. Experimental studies of atmospheric diffusion will be extended to distances of the order of 15 miles at Hanford and 50 miles or more at Brookhaven, utilizing highly sensitive tracer techniques and three-dimensional sampling.

5. Dosimetry and instrumentation, $2,767,000

(*a*) *Dosimetry.*—Fiscal year 1958, $501,381; fiscal year 1959, $534,000; fiscal year 1960, $695,000.

(*b*) *Instrumentation.*—Fiscal year 1958, $1,482,832; fiscal year 1959, $1,964,000; fiscal year 1960, $2,072,000.

The development of instruments and special techniques for measuring nuclear radiation and its effects on biological systems is a prerequisite to biomedical research, radiation protection, and control of radiation hazards. The following areas of research and development will be continued and expanded by fiscal year 1960:

(1) Specific problems related to methods for detecting ionizing radiations will receive continuing emphasis. For example, studies currently in progress are expected to result in ion tracks visualization in solid scintillators. Further research utilizing transistor techniques is expected to result in radiation survey meters with increased sensitivity, accuracy, and reliability. Development efforts for monitoring equipment for high energy radiation from accelerators will be continued.

(2) Expansion of instrumentation research is also planned in the area of low-level counting equipment. The further development of whole body counting facilities will be supplemented by a continuation of the basic study of the mechanism of scintillating materials and of special photomultiplier tubes. Development of low-level soft beta gas counting tubes will also continue at an increased rate.

(3) Research in environmental dosimetry including neutron spectrum data for health protection will be expanded. Present work in the development of tissue equivalent plastics and ionization chamber dosimeters will be continued.

(4) The need for electronic and electromechanical systems capable of processing electric signals from the detector elements of instruments will result in continuing research and development in this area. For example, an automatic scanning device in association with an electronic computer and data reduction system for counting binucleated lymphocytes as a measure of whole body exposure will be studied. Instruments for telemetry of radiological and meteorological measurements will be further refined through continued research.

(5) Instrumentation for pulse height analysis will be developed to the limit of high-speed acceptance of pulses. This capacity is needed when pulses are delivered in bursts of short duration, as from accelerators. Several approaches to this problem underway in fiscal year 1959 will be continued in fiscal year 1960.

(6) The successful development of special radiation detection probes for the brain will be followed by the design of detectors with unique form factors for in vivo measurement of radiation in other organs.

6. Civil effects

Fiscal year 1958, $725,220; fiscal year 1959, $892,000; fiscal year 1960, $1,500,000.

Continued research in the civil effects program is required to provide the data needed to permit sound planning for defense against effects of nuclear weapons, accidents, or disasters involving weapons, and other applications of nuclear energy. Therefore, suspension or cessation of tests requires more extensive analysis of data from past tests and from the Japanese detonations, and more extensive use of laboratory and nonnuclear field studies to obtain critically needed data.

The Ichiban project will be continued at the Oak Ridge National Laboratory, using available radiation sources, for correlation with field data from the Atomic Bomb Casualty Commission.

A combination of laboratory and field investigations are planned to continue and supplement studies which have been conducted at the Nevada test site

during fiscal year 1958 and fiscal year 1959 in the following areas: (*a*) radiation decontamination; (*b*) radiation shielding; (*c*) thermal and blast effects; (*d*) fallout. Structures and facilities both at the Nevada test site and at other installations will be utilized for these studies.

The studies of fallout deposition, biological availability of fallout materials, physical and chemical characteristics of fallout, and biological significance of fallout will continue.

The program to survey radiation background over the entire United States including parts of Alaska through the aerial radiobiological survey of the U.S. Geological Survey will be continued in fiscal year 1960. Of particular importance will be the data obtained on radiation background at Commission contractor and licensed reactor sites.

Consonant with the national plan for civil defense and defense mobilization announced in October 1958, setting forth the respective responsibilities of the Office of Civil and Defense Mobilization and other Government agencies, the Commission will sponsor extensive experiments and training exercises and community protection against fallout. These pilot studies of countermeasures and decontamination procedures will provide for practical application of information and data on protection against fallout, for use by AEC in strengthening the civil defense of its communities and headquarters building.

7. Equipment not included in construction projects, $2,012,000

Equipment requirements for the support of biology and medicine research programs at Commission-operated and university laboratories are estimated to cost $2,012,000 in fiscal year 1960, a net increase of $186,000 over fiscal year 1959. The increases over normal laboratory and shop equipment are accounted for as follows:

(*a*) A 250-kilovolt X-ray machine, thermal eddy grid, and automatic analytical equipment are required for Argonne National Laboratory.

(*b*) A tritium-carbon scintillation counter, activation analysis equipment, multiple-foci patient scanner, and other equipment are required for use in the new medical center at Brookhaven National Laboratory.

(*c*) The expansion of the biomedical program at offsite laboratories will result in an accompanying increase in equipment needs for items not ordinarily available in university laboratories, including specialized X-ray equipment and controlled low-level counting facilities.

The reduction in equipment for the New York Health and Safety Laboratory will result from the completion of its relocation to Varick Street.

There follows a breakdown of the total equipment costs indicating amounts estimated for each major installation in relationship to its other operating costs under this program.

[In thousands of dollars]

Installation	Other operating costs	Equipment costs
Argonne Cancer Research Hospital	2,000	60
Argonne National Laboratory	3,829	269
Atomic Bomb Casualty Commission	1,998	65
Brookhaven National Laboratory	4,340	300
General Electric Co., Hanford	2,075	90
Health and Safety Laboratory, New York	1,754	85
Oak Ridge Institute of Nuclear Studies	1,055	95
Oak Ridge National Laboratory	4,958	217
University of California at Los Angeles	1,379	50
Lawrence Radiation Laboratory	2,102	100
University of Rochester	1,711	79
All other	19,787	602
Total	46,988	2,012

STUDY OF EFFECTS OF RADIATION

Mr. CANNON. What are the principal reasons for the increase of $6 million requested for this program, Mr. Chairman?

Mr. MCCONE. This is Dr. Dunham, Mr. Chairman, who is Director of our Division of Biology and Medicine.

Dr. DUNHAM. The principal reason for an increase at this time is to get on with a planned expansion of that part of our program which has to do with providing much more definitive information on the effects of radiation on living systems. It is that part of the program, plus the extension of the program in collecting data in order to understand the mechanisms of transport of fallout from the detonation of atomic weapons. Those are the two areas in which the increase largely falls.

Mr. CANNON. The committee will stand adjourned until 1:30.

(AFTERNOON SESSION)

DIVISION OF RESPONSIBILITY BETWEEN AEC AND PUBLIC HEALTH SERVICE

Mr. CANNON. Doctor, there has been some controversy reflected in proposed legislation concerning the division of responsibility between the AEC and the Public Health Service in the matter of health hazards from nuclear sources. Will you tell us something about these conflicting interests?

Dr. DUNHAM. This particular subject, Mr. Chairman, is under very careful review now by the Bureau of the Budget. I do not know what final recommendations they will make.

Certainly under existing legislation the Atomic Energy Commission has very clear-cut responsibilities in conducting its operations consistent with the health and safety of the people.

Mr. CANNON. Would you say it amounts to duplication?

Dr. DUNHAM. There is a fairly large area in the field of radiation health, which comes under no very specific Federal control except as a general health problem. There is no agency with statutory authority to deal with radiation hazards associated with the thousands of X-ray machines which are used in industry and in the practice of medicine, nor is there any special legislation concerning radium or cyclotron-produced radioisotopes, so there is an area in which there is not comparable authority and responsibility in any Federal agency to that which the Atomic Energy Commission has in the field of atomic energy and reactor-produced radioisotopes.

Mr. CANNON. Do you think anything remains to be determined legislatively in that respect?

Dr. DUNHAM. I would prefer to have the Chairman discuss that. I thing he is in a better position to speak for the administration than I would be.

Mr. MCCONE. I would be inclined to feel, Mr. Chairman, that the responsibility and authority as provided by the law places on the Atomic Energy Commission certain responsibilities which are adequate.

I think there has grown up a feeling that the Atomic Energy Commission cannot discharge its legal responsibility properly in the interests of public health and safety because of the so-called conflict of interest.

They are, on the one hand, the developers of nuclear resources, and on the other hand they are charged with the responsibility for public health.

I myself am not concerned about that conflict. I do not think it is as serious as it has been reported.

I think, however, it would be well for the Department of Health, through the Secretary of Health, Education, and Welfare, to be consulted with regard to the matters of public health should at any time you give consideration to future weapons tests, let us say.

I think perhaps it has been unfortunate that in this area the Department of Health has not been consulted.

I think if we were to conduct any further tests most certainly arrangements would be made so that their views would be obtained.

It might be that the Department of Health could play a more active role in correlating information on radioactivity and fallout and informing the public and in certain analyses of situations which might relate very intimately to their responsibilities under the Food and Drug Act. This is under active discussion at the present time between the Secretary of Health, Education, and Welfare, myself, and the Director of the Bureau of the Budget.

Mr. CANNON. You think that any conflict of responsibility, then, could be resolved administratively?

Mr. MCCONE. I think so.

RESEARCH CONTRACTS

Mr. CANNON. What is the machinery through which research contracts are granted and how do you evaluate the accomplishments?

Mr. MCCONE. Dr. Dunham can review that in detail.

Mr. CANNON. What is the routine, Doctor, and how do you estimate your accomplishments?

Dr. DUNHAM. Routinely, either at the suggestion of one of my staff that we would have an interest in a particular scientist's activities, or on the initiative of that scientist, he sends through his institution's administrative people, whether it be a hospital, a university, or a commercial laboratory or institute, a research proposal telling us what he proposes to do, telling us how much support goes toward this project from the institution itself, and how much he would like to have in the way of assistance from the Atomic Energy Commission in order to carry out this work properly.

He also tells us whether he is getting support from any other Federal agency or from the Cancer Society or from some other organization.

He details who will be the principal investigator and who will be the principal assistant, and he provides us briefly a biographical sketch of each.

He also informs us how much equipment is needed and the number of technicians to do the job.

Our staff then looks at this proposal, and if it is a brandnew one it is sent to two or three distinguished scientists around the country who are experts in the particular field to comment on the competency of the proposal and the plan of research, and also they will usually indicate whether they feel that the money requested is consistent with the scope of the work.

Then it is reviewed again in my division under Dr. Shilling here, who is in charge of our entire research effort, in a committee in which they discuss this particular project, rate it according to its merits, and also according to the degree of interest to the Commission that that

particular proposal has, whether it is something that is within the mission of the Atomic Energy Commission.

Then a determination is made as to whether or not it should be supported.

Mr. CANNON. You sometimes find, then, it is not within your purview?

Dr. DUNHAM. Definitely, and in that case we may find it is a very fine piece of basic research but not basic research that is supportive to our program, and we may suggest that they approach the Science Foundation or approach one of the National Institutes of Health, or some other organization, depending upon the nature of the work.

Mr. CANNON. We should be glad to have you give us the table you gave us last year concerning the off-site contracts.

Dr. DUNHAM. We will be glad to do that, sir.

Mr. CANNON. As it appears on page 1087 of last year's hearings.

(The information requested follows:)

Division of biology and medicine—Schedule of fiscal year 1959 off-site research contract renewals

Number of years of support	Number of contracts	Fiscal year renewal amount
Less than 3	109	$2,267,987
3 to 5	129	2,628,387
5 to 10	192	4,928,744
10 or more	26	1,438,918
Total	456	11,264,036

Mr. CANNON. Is there further inquiry on the branch of biology and medicine?

PUBLIC HEALTH SERVICE REPRESENTATIVE IN THE AEC

Mr. FENTON. Along the lines of the questioning of the Chairman regarding any conflicts of responsibility, does the USPHS have a representatives in the Atomic Energy Comission?

Mr. MCCONE. They have no representative in the Commission as such. We collaborate and work very closely with the Public Health Service in all matters relating to public health.

Mr. FENTON. Do you get any cooperation from the Public Health people and do you think it would be well to have representatives of theirs on your staff?

Mr. MCCONE. I had not thought of their having representatives on the staff of the Atomic Energy Commission. Our activities and our operations are open to them and we are in frequent and continual consultation and discussion with them. I do not know that an actual assignment of people there would be of any particular value, Doctor.

PERSONNEL IN DIVISION OF BIOLOGY AND MEDICINE

Mr. FENTON. Dr. Dunham, how many people work in your Division of Biology and Medicine? Do you have any specialists in medicine?

You mentioned a number of studies and various other things.

Dr. DUNHAM. We have on my immediate staff in the Commission 21 Ph. D.'s and 4 M.D.'s, including myself.

These include two geneticists. We have always had at least one geneticists on the staff of the Division. We have one toxicologist, a physiologist, three biochemists, a soil chemist, an ecologist, a limnologist, two biophysicists, and several radiologicial physicists, a few general radiobiologists, and a meteorologist. These are my immediate professional staff.

Mr. FENTON. The reason I brought that up was because you mentioned the number of studies being made. It would certainly be to the benefit of everybody concerned to make those efforts.

Dr. DUNHAM. We make every effort to do this. As you can see from the list I gave you, we do not cover every single specialty. We cannot. This is the reason we call on specialists outside of the Commission, in order to give us guidance in a general way through our Advisory Committee on Biology and Medicine which advises the Commission on biological research and health matters, and through independent scientists, either at our national labs or at universities.

Mr. FENTON. That is all, Mr. Chairman.

TRAINING, EDUCATION, AND INFORMATION

Mr. CANNON. On "Training, education, and information," I shall ask the reporter to insert pages 184 through 205.

(The pages follow:)

TRAINING, EDUCATION, AND INFORMATION—OPERATING COSTS

Program statement

Estimate fiscal year 1960	$14,800,000
Estimate fiscal year 1959	13,700,000
Increase	1,100,000

The training, education, and information program is designed to broaden the base of nuclear knowledge and technology at home and abroad. Program efforts are directed toward the provision of assistance to colleges and universities in establishing nuclear curricula; the operating, through contract, of schools, and the conduct of specialized courses; offering of graduate fellowships in the nuclear energy field, presentation of international conferences, studies, and exhibits; and the organization and dissemination of technical information.

Stimulated to a large extent through assistance provided by the Commission, the capability of American colleges and universities to provide fundamental nuclear energy curricula has shown continued improvement. Reflecting this trend, Commission emphasis is shifting from support of schools such as the Oak Ridge School of Reactor Technology, and the Argonne International Institute of Nuclear Science and Engineering (formerly called Argonne International School of Nuclear Science and Engineering), which provided basic nuclear curriculum, toward more advanced type of courses providing special training opportunities to qualified participants. Termination of classes at the Oak Ridge School of Reactor Technology, transition to more advanced curriculum at the Argonne International Institute as well as the offering of specialized courses at Shippingport, the Oak Ridge National Laboratory and the New York Health and Safety Laboratory attest to the changing emphasis of Commission activity in this area.

The program of assistance to schools including financial grants for the purchase of training equipment, the provision of materials and teaching aids for use in classrooms, and the provision of special training opportunities for qualified faculty will be continued in an effort to meet the long range needs of the atomic era by providing a solid foundation for increasing the numbers of

technical manpower adequately prepared in the field of fundamental nuclear energy technology.

The increasing importance of atoms-for-peace activities as an integral part of U.S. foreign policy places a continuing responsibility on the Commission to provide special nuclear opportunities for foreign nationals and to provide advisory and consultant services to regional groups of countries such as the Organization of American States, etc. In addition, programs involving support of nuclear topical conferences and the presentation of overseas nuclear energy exhibits are being pursued.

In carrying out its responsibilities for the dissemination of scientific and technical information, the Commission operates a museum and traveling exhibits; prepares books, technical reviews, and information releases; translates foreign language scientific materials; maintains classified depository libraries; and operates a nuclear science information service.

Summary of estimates by category

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
1. Training and education in reactor technology	$6,798,350	$3,557,000	$5,200,000
2. Training and education in radiobiology and the life sciences	2,283,548	2,538,000	3,150,000
3. Training and education of foreign nationals in nuclear science and technology	1,329,261	1,600,000	2,185,000
4. Information services	2,911,287	2,930,000	3,115,000
5. International conferences, exhibits, and studies	2,131,418	3,075,000	1,150,000
Total training, education and information program	15,453,864	13,700,000	14,800,000

JUSTIFICATION OF CATEGORIES

1. *Training and education in reactor technology, $5,200,000*

The primary purpose of this program is to assist colleges and universities to develop teaching capability in nuclear science and engineering in order to meet the increased needs for men and women trained in these areas of increasing national importance. This purpose is pursued by a three-pronged approach—granting financial and nuclear material assistance to the universities for lecture and laboratory demonstrations, providing special training opportunities for qualified faculty members, and providing graduate fellowships to assure a reasonable number of top quality students. Along with these activities directed toward the long-range needs of the growing nuclear industry is a program for meeting current manpower needs through highly specialized short courses and job training opportunities at AEC sites. Since colleges and universities are providing ever increasing opportunities for education in the nuclear field, the training program in reactor technology is shifting emphasis from support of formal educational programs at AEC sites toward providing highly specialized courses and on-the-job training for university faculty and students.

Funds requested for fiscal year 1960 will continue the programs in nuclear science and engineering for increasing the supply of technical manpower adequately prepared for the nuclear era.

Summary of estimates by activity

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Training and education in reactor technology:			
(a) Operation of schools	$379,836	$200,000	$200,000
(b) Fellowships	248,002	375,000	550,000
(c) Assistance to schools	6,014,779	2,832,000	4,250,000
(d) Other training, education, and information activities	155,733	150,000	200,000
Total training and education in reactor technology	6,798,350	3,557,000	5,200,000

(a) *Operation of schools, $200,000.*—The following is a summary of the items in this activity:

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Oak Ridge School of Reactor Technology	$379,836	$100,000	0
Shippingport program for reactor supervisors	0	100,000	$200,000
Total operation of schools	379,836	200,000	200,000

The Oak Ridge School of Reactor Technology, established as an interim measure to fill AEC and industry training needs at a time when universities had few offerings in the nuclear field, fulfilled its primary function and was closed in August of 1958.

As the program for AEC and privately supported power reactors continues to expand, there is increased need for trained personnel to operate these reactors. The AEC has an obligation to help meet this need by providing training for supervisory personnel, who, in turn, will train personnel at lower echelons. In fiscal year 1959, a training program was established at Shippingport for supervisory personnel of those companies having firm commitments to design or operate power reactors. This course emphasizes basic technical knowledge and operating maintenance experience gained from Shippingport power reactor operations. Tuition charges of $2,000 per student have been established. The increase in fiscal year 1960 represents a full year's operation of the course.

(b) *Fellowships, $550,000.*—The AEC special fellowship program in nuclear science and engineering provides for 150 students taking advanced work in nuclear science and engineering. The primary purpose is to encourage a group of high caliber students to enter the nuclear field. As a secondary benefit, it encourages universities to develop well rounded nuclear curriculums. The increase in fiscal year 1960 is required to cover increasing tuition costs and increased stipends and dependency allowances.

(c) *Assistance to schools, $4,250,000.*—Assistance in the form of equipment grants, provisions of nuclear materials and services, courses of instruction for university and technical institute faculty, and research and on-the-job training opportunities for faculty and students are offered to educational institutions as an inducement to assume greater responsibility for education and training in the field of nuclear science and engineering. The programs are interrelated, and universities usually participate in all these activities. As an example, the universities participating in the followship program have all participated in these assistance programs. Under the equipment grant program, universities are provided funds for the purchase of nuclear laboratory equipment including teaching reactors, reactor simulators subcritical assemblies, and other unique apparatus for instructing students. In addition, AEC lends, without charge, special nuclear materials not commercially available, fabricates neutron sources, reprocesses spent fuel elements and performs a number of additional services for universities. The increase in this estimate for equipment grants and nuclear materials results from the large backlog of requests for assistance from qualified institutions.

In cooperation with the American Institute for Engineering Education, summer institutes in nuclear technology are offered for faculty members of colleges, universities and technical institutes to develop faculty competence in the nuclear energy field. Wherever feasible, formal educational programs are offered on university campuses, with the AEC sites offering opportunities for courses utilizing highly specialized equipment not normally found on university compuses. In addition, both students and faculty are provided opportunities for research work and on-the-job training at AEC contractor sites. Increased operating costs reflect the additional costs of specialized and on-the-job training required as additional training for faculty members who have taken the basic courses. Since over 200 faculty members have taken basic courses, they can now be expected to apply for advanced training at higher per capita costs.

The following is a summary of the items in this activity:

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Reactor training equipment grants	$5,399,959	$2,265,000	$3,100,000
Development of pedagogical tools	96,965	50,000	0
Summer institutes for engineering faculty	329,288	300,000	350,000
Research participation program in reactor technology	36,968	50,000	100,000
Materials and services	151,599	167,000	700,000
Total assistance to schools	6,014,779	2,832,000	4,250,000

(*d*) *Other training, education, and information activities, $200,000.*—In addition to the specific activities listed above, a variety of miscellaneous activities are needed to round out the program: short courses in specialized subjects, seminars, textbooks, teaching aids, films, and curriculums development. Demands for these items are expected to increase due to the expanded interest of technical institutes in establishing technician training programs, and the impetus to be expected from the universities recently incorporated as the Associated Midwestern Universities cooperating with the Argonne National Laboratory. The Argonne National Laboratory, mainly through its International Institute of Nuclear Science and Engineering, has developed many worthwhile experimental and teaching techniques. Making these aids available to universities will be of considerable assistance in decreasing the time necessary to establish broad nuclear curriculums as the faculty of many institutions are not aware of the sources of this kind of information.

2. Training and education in radiobiology and the life sciences, $3,150,000

The training, education, and information costs incurred under this category are those related to the life sciences. Included in this program are costs for operating the Oak Ridge Institute of Nuclear Studies, assistance to educational institutions through financial grants for training equipment and training aids, faculty training, and the conduct of a fellowship program.

Summary of estimates by activity

Training and education in radiobiology and the life sciences	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
(*a*) Operation of schools	$230,871	$202,000	$256,000
(*b*) Fellowships	371,597	479,000	600,000
(*c*) Assistance to schools	1,479,530	1,630,000	1,919,000
(*d*) Other training, education, and information activities	155,742	181,000	265,000
(*e*) Equipment not included in construction projects	45,808	46,000	50,000
Total training and education in radiobiology and the life sciences	2,283,548	2,538,000	3,150,000

(*a*) *Operation of schools, $256,000.*—The following item is included in this activity:

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
(1) Oak Ridge Institute of Nuclear Studies: Total	$230,871	$202,000	$256,000
Traveling science teachers program	44,104	48,000	100,000
Special training program (radioisotopes)	186,767	154,000	156,000

An important training activity which will be expanded in fiscal year 1960 is the traveling science teachers program wherein specially selected teachers employed in high schools of the country receive 3 months of intensive training at the Oak Ridge Institute of Nuclear Studies. During the subsequent school year, they visit high schools throughout the States disseminating to the schools visited the specialized knowledge and background acquired during their training at ORINS. They then return to their regular teaching posts at the end of their year's appointment. The training at ORINS includes special lectures in chemistry, physics, mathematics, and biology as related to nuclear science, as well as instruction in teaching and laboratory demonstration techniques. In the field, after the training period, they spend a week at each scheduled high school lecturing (with demonstrations) and conferring with students, teachers, and administrators. This has become an increasingly effective program in extending special knowledge, stimulating interest in science, science careers, and teaching, and has extended beyond the high school level to adult groups, i.e., civic clubs, etc. The Commission's budget for this program covers the costs of demonstration material and administration, with the costs of teacher's salaries, transportation, and other items being shared by the National Science Foundation and State boards of education. To date under this program, requests for visits have been received from 5,000 schools of which approximately 1,000 have been visited.

The special training program (radioisotopes) has the primary purpose of training research workers in the use of radioactive materials, and will continue at approximately the same level. One of the major courses offered is the basic radioisotope techniques course which emphasized instrumentation, radiation detection, and the safe handling of radioisotopes. Other special and advanced courses, lasting from 1 to 4 weeks, are offered in special fields of medicine, biochemistry, industry, and radiography; a series of special courses has been offered in veterinary radiological health.

Through fiscal year 1958, well over 3,000 persons have participated in the special training program, including scientists from every State in the country, the District of Columbia, Puerto Rico, Hawaii, and 47 foreign countries.

(*b*) *Fellowships, $660,000.*—

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Radiological physics	$258,937	$334,000	$460,000
Industrial hygiene	26,950	45,000	50,000
Industrial medicine	85,710	100,000	100,000
Advanced graduate study (radiological physics)	0	0	50,000
Total fellowships	371,597	479,000	660,000

The above schedule provides a breakdown of the estimate for fellowships. As the peacetime uses of atomic energy continue to develop, the need for additional trained specialists in the above-listed fields becomes more acute. Of particular importance is the critical need for trained personnel in radiological physics. Included in the estimate for radiological physics fellowships are funds for a substantial expansion in a subprogram which provides special assistance for training in radiation control. This program emphasizes the public health aspects of radiation control and is designed to provide special training to State public health and industrial hygiene employees. Under this program it is expected in fiscal year 1960 to train approximately 25 State employees with the expectation that these trained individuals will assist in the fulfillment of radiological health inspection responsibilities. A long-range view of this program indicates that approximately 50 highly trained persons in radiation protection will provide a nucleus around which an efficient radiation protection program can be developed by the States.

There is also included in the estimates a new program for an advanced graduate study in radiological physics. The shortage of scientists in this particular field make such a program extremely urgent. There is presently no adequate source of people with the doctoral degree to direct large health physics programs. Through this program suitable people in the ranks of health physics who have demonstrated ability and interest in the fieldwork will be identified and enabled to take advance training for the doctoral degree.

(c) *Assistance to schools, $1,919,000.*—This activity provides funds for educational programs of assistance to high schools, colleges and universities, including financial grants for training equipment and training aids, and faculty training.

The following is a summary of the items in this activity:

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
(1) Life sciences training equipment grants	$1,165,480	$1,100,000	$1,100,000
(2) Faculty training	314,050	530,000	819,000
Radiobiology training for high school science teachers	314,050	450,000	600,000
Radiobiology lecture series	0	10,000	10,000
Radiobiology training for college faculty	0	70,000	159,000
Advanced radioisotope training, medical	0	0	50,000
Total assistance to schools	1,479,530	1,630,000	1,919,000

The program of life sciences training equipment grants was begun in fiscal year 1958 to assist nonprofit educational institutions by awarding financial grants for the acquisition of special equipment and demonstration apparatus necessary to present laboratory course work in nuclear technology as applied to the life sciences. Equipment secured through these grants is intended specifically for teaching aids rather than for research activities. The rapid technological advancement and increasing biological implications in the field of nuclear energy create a proportionate need for more and better trained scientists in the field of radiation biology generally, and the use and handling of radioisotopes specifically. This program meets the Commission's responsibility in this area. Grants are available to medical schools, schools of pharmacy, agricultural colleges, biological divisions of liberal arts colleges and universities, and schools of public health.

The major course under the faculty training program is that in radiobiology training for high school science teachers. This course in general is designed to contribute to the national effort toward increasing the number of scientists in the special and still new field of nuclear technology by (1) introducing the fundamentals of the field to high school teachers and thus to their students, and (2) by attracting individuals toward scientific careers at this appropriately early educational level. The increase in this program will allow for an expansion from 15 to 20 summer institutes with a continued effort to locate these institutes geographically throughout the United States. This program is administered in cooperation with the National Science Foundation, with the Foundation providing the cost of stipends and family allowances and the Commission providing the funds to cover demonstration material and operational costs.

The radiobiology lecture series program provides lecturers from among scientists recognized for their work and competence in the research field of radiation biology to colleges and universities. Costs under this program include transportation, per diem, and fees for lecturers not otherwise compensated by the Atomic Energy Commission.

Complementing the program of radiobiology training for high school science teachers is the program commenced in fiscal year 1959 of training in radiation biology at the college level. In order that curricula may be initiated in the field of radiation biology in institutions of advanced learning, it is necessary to train qualified faculty from colleges and universities throughout the United States. Approximately 40 individuals will be trained under this program in fiscal year 1960.

A new program, advanced radioisotope medical training, consisting of a concentrated course of special training in the medical applications of radioisotopes is proposed. Arrangements with an accredited medical school will be made for courses to be offered in an academic year or in summer sessions, or possibly both, for physicians from the U.S.A. and foreign countries. The basic course in radioisotope techniques (offered at Oak Ridge Institute of Nuclear Studies) does not provide an opportunity for study of the use of radioisotopes in medical or other special fields of usage. This proposed course will provide the applied use of isotopes in clinical practice, diagnostic applications, therapy, etc.

(d) *Other training, education and information activities, $265,000.*—The estimate provides for the conduct of on-the-job and laboratory training for the

recipients of fellowships in radiological physics, industrial hygiene, and industrial medicine. Supplemental to the academic training received at the universities, the inplant year of training is given at the AEC contractor installations, and other areas where there are major industrial medical units. The costs provide for salaries of part-time laboratory assistance, stipends of occasional special lecturers, and supplies for courses.

Costs in this activity also provide for the miscellaneous items occurring each year such as cost of revisions to keep current the teaching manual prepared in 1959; tot continue a minimal supply of isotopes for graduate teachers, etc.; necessary replacement of items of demonstration apparatus to teacher-students of summer institutes, high school and college.

(*c*) *Equipment not included in construction projects, $50,000.*—The estimate provides for equipment requirements directly related to the training, education, and information program. A major requirement is for general purpose equipment required by the Special Training Division at the Oak Ridge Institute of Nuclear Studies. Known items now urgently required include medical spectrometers for use in clinical training; a lowlevel anticoincidence counter, and special industrial equipment and working models for the radioisotope training course. Planned replacement based on normal usage and obsolescence and miscellaneous additional items which may be required are also budgeted. There follows a comparison of other operating costs with equipment costs for training and education in radiobiology and the life sciences.

	Other operating costs	Equipment costs
Oak Ridge Institute of Nuclear Studies	$256,000	$50,000
All other	2,844,000	0
Total	3,100,000	50,000

3. Training and education of foreign nationals in nuclear science and technology, $2,185,000

The increasing importance of atoms-for-peace activities as an integral part of U.S. foreign policy places a continuing responsibility on the Commission to implement agreements for cooperation. Important implementing activities implicit in such agreements include the provision of special nuclear training opportunities for foreign nationals and the provision of advisory and consultant services to regional groups of countries such as the OEEC.

The Commission has developed and sponsored training courses which enroll foreign nationals at various facilities. Many colleges and universities both in the United States and abroad now provide facilities and courses covering basic nuclear training. Therefore, it is no longer necessary for the Commission to sponsor basic nuclear courses, and they are being discontinued. However, the rapid advance of nuclear technology; the importance of maintaining U.S. influence in international scientific groups; our obligation to the International Atomic Energy Agency, and Euratom, as participants; the desirability of exposing international nuclear scientists to U.S. industrial products—all contribute to the continuing need for U.S. sponsored high level and specialized training courses for foreign nationals. In view of the wide availability of training at the university level, Commission support of nuclear training is confined to the more advanced level curriculum.

Summary of estimates by activity

Training and education of foreign nationals in nuclear science and technology	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
(*a*) Operation of schools	$862,139	1,182,000	$1,680,000
(*b*) International conference, exhibits, and studies	148,719	100,000	200,000
(*c*) Equipment not included in construction projects	318,403	318,000	305,000
Total, training and education of foreign nationals in nuclear science and technology	1,329,261	1,600,000	2,185,000

(a) *Operation of schools, $1,680,000.*—The Commission's provision for advanced nuclear training on an international scale constitutes an important contribution to the atoms-for-peace program. The courses offered in these training programs are changing in emphasis to reflect technical advances in nuclear scientific disciplines and to stimulate participation of the highest level scientists. Accordingly, constant reviews are made to meet the needs and objectives of the atoms-for-peace program and to modify the courses so that they will not be in competition with training facilities and courses offered in universities, institutions, and industry. The provision of high level training opportunities in advanced nuclear sciences assures U.S. leadership in the increasingly important international scientific community.

The following is a summary of the items in this activity:

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
(1) International Institute of Nuclear Science and Engineering	$734,571	$645,000	$780,000
(2) Puerto Rico Nuclear Center	127,568	425,000	745,000
(3) Health and safety laboratory course	0	12,000	15,000
(4) Reactor hazards and supervisors course	0	100,000	140,000
Total operation of schools	862,139	1,182,000	1,680,000

With the increased availability of nuclear energy curriculums at colleges and universities, it has become desirable to advance the level of work offered by the international school and to change its name from the "International School of Nuclear Science and Engineering" to the "International Institute of Nuclear Science and Engineering." There are three major objectives in the transition from the International School to the International Institute. They are: (1) To raise the level and specialization of work to meet advancing scientific and technical development, (2) to meet the need for foreign and domestic training in the atoms-for-peace program, and (3) to adjust Commission sponsored training to assure that this training is not competitive with that offered in universities and industrial institutions.

Increasing the breadth of offerings and raising the level of study will include advanced training in the physical and life sciences and in the engineering, technical management, and operation requirements for nuclear facilities. The proposed courses include advanced theory of reactor design and technology, special engineering, research and development problems, applied chemical, physical, and biological studies, and reactor and nuclear facilities technical management seminars. A prerequisite to participation at this Institute is a high level professional and scientific education. No preliminary instruction or basic course offerings, such as those previously conducted for the Commission by Pennsylvania State and North Carolina State Universities, will be offered or sponsored. A subsantial majority of the applicants for scientific training to the International Atomic Energy Agency have indicated preference for nuclear training in the United States. It is anticipated that those students meeting the professional requirements of the Institute will be enrolled here to fulfill the commitments the United States has made to the Agency.

It is expected that a total of 120 participants will be accommodated at the Institute during fiscal year 1960. The total number will depend upon individual training arrangements of the participants. This training will be provided upon payment of tuition fees of $1,000 per semester with two formal semesters of training provided at the Institute during fiscal year 1960. The increase in fiscal year 1960 is due primarily to the additional number of man-years for instruction and additional equipment required in this more diversified and higher level of training.

The Puerto Rico Nuclear Center, including the reactor and laboratory facilities, will be completed and operating at capacity during the third quarter of fiscal year 1960. The increase in cost for fiscal year 1960 is primarily for costs of additional instructors' salaries and expendable supplies necessary for the increased training activities. Medical and clinical science activities were conducted for approximately 6 months during fiscal year 1959, and are planned for a full year in fiscal year 1960.

In order to provide specialized nonacademic instruction in monitoring techniques and radiochemical counting procedures, a course was initiated in October 1958 at the New York operations officer health and safety laboratory. There is no indication that universities or non-AEC facilities will be able to provide similar instruction through fiscal year 1960. This program consisting of 4 courses per year, each of 6 weeks' duration, accommodating 6 students, permits 24 students to be trained each year. A registration fee of $25 is charged each participant.

The instruction includes use of low level counting equipment, identification and determination of activity of specific radioisotopes, the development of specialized analytical methods, the distribution of fission products in the atmosphere, and the philosophy and interpretation of measurements.

The amount requested for fiscal year 1960 provides for a full year's operation of the monitoring techniques course.

Two advanced specialized courses not previously available in the United States were initiated in fiscal year 1959 at the Oak Ridge National Laboratory. The reactor supervisors course prepares students to manage the operation of research and power reactors. This 9 months' course is directed toward technical management problems and the development of proficiencies necessary for managing reactor facilities. A 1-year course covering reactor hazards evaluation was designed to train students to evaluate activities encountered in the operation of reactors and critical experiments. These courses are highly technical and specialized. Equivalent instruction is not available at universities and industrial institutions.

It is anticipated that these courses will be offered to approximately 20 applicants during fiscal year 1960. A tuition fee of $2,000 per student is charged. This amount is reflected in the revenues section of the budget and has not been deducted from the costs shown here. While these courses are primarily for foreign nationals, enrollment of a few U.S. citizens is encouraged. The $140,000 requested is a gross cost covering salaries of instructors, expendable supplies, and general overhead.

(*b*) *International conferences, exhibits, and studies, $200,000.*—The following item is included in this activity:

Advisory services:	
Fiscal year 1958	$148,719
Fiscal year 1959	100,000
Fiscal year 1960	200,000

The estimate for this activity provides for advisory and consultant services to regional groups of countries such as the Organization of European Economic Cooperation, Euratom, etc. (excluding however the IAEA, and the U.N.). It also provides for U.S. participation in meetings, conferences, and symposia sponsored or cosponsored by these groups. The consultant and advisory services will be provided by individuals or small groups of experts under contract to AEC who will travel to the headquarters of these organizations or to member countries to assist in the evaluation and development of atomic energy programs.

The provision of such advisory and consultant assistance to these groups of countries, constitutes an important contribution to the atoms-for-peace program and will materially contribute to the acceleration of peaceful atomic energy activities in many cooperating countries. In addition, these activities will permit U.S. representatives to obtain first hand information on current technological advances achieved by the member countries of these organizations.

(*c*) *Equipment not included in construction projects, $305,000*—(*1*) *Puerto Rico Nuclear Training Center, $255,000.*—This estimate will provide: (1) a mass spectrograph, spectrometer, centrifuge, and other equipment necessary for nuclear science courses amounting to a total of $60,000; (2) a pool type subcritical assembly, gamma irradiation source holder, monitoring devices, counters, neutron spectrometer and miscellaneous laboratory equipment totaling $125,000 for the research reactor program; (3) approximately $25,000 for miscellaneous experimental equipment for cancer training and research; (4) $30,000 for counters and special laboratory devices to conduct radioisotopes and radiological physics courses; and (5) $15,000 for office equipment for the administrative offices at Mayaguez and Rio Piedras as well as two automobiles for communication between these two sites which are approximately 150 miles apart.

(*2*) *International Institute for Nuclear Science and Engineering, $50,000.*—The special equipment required includes replacement of shop and office equip-

ment totaling $25,000, equipment and instrumentation for the Argonaut reactor estimated at $20,000, and $5,000 for special equipment needed in metallurgy and chemistry laboratories. There follows a summary of other operating costs compared with equipment costs estimated for training and education of foreign nationals in nuclear science and technology.

	Other operating costs	Equipment costs
Puerto Rico Nuclear Center	$745,000	$255,000
International Institute of Nuclear Science and Engineering	780,000	50,000
All other	355,000	0
Total	1,880,000	305,000

4. Information services, $3,115,000

The purposes of this program are to provide for the dissemination of scientific and technical information to meet the needs of the general public, and particularly of educators, scientists, businessmen and industrialists, for information concerning scientific and technical developments in the national atomic energy program, and to provide technical information services and materials within the AEC and to AEC contractors. These objectives are accomplished by (1) operation of a museum exhibits and school demonstration units, (2) preparation of books, periodic technical reviews and technical information releases for the business and industrial community, (3) translation of foreign language scientific materials, and (4) operation of the Technical Information Service Extension at Oak Ridge, which provides classified and unclassified central AEC nuclear science information services.

Summary of estimates by activity

Information services	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
(a) Museums and exhibits	$603,873	$630,000	$620,000
(b) Publications and libraries	2,270,258	2,267,000	2,455,000
(c) Equipment not included in construction projects	37,156	33,000	40,000
Total information services	2,911,287	2,930,000	3,115,000

(a) *Museum and exhibits, $620,000.*—The Commission's responsibility under the Atomic Energy Act of 1954 to provide for the dissemination of unclassified scientific and technical information is carried out in part by means of a museum and other visual presentations exhibiting peacetime applications of atomic energy. The American Museum of Atomic Energy located at Oak Ridge and operated for the Commission by the Oak Ridge Institute of Nuclear Studies, serves as an education information center for visitors from all parts of the United States and from foreign countries. The Commission's traveling exhibits program, also operated for the Commission by ORINS, serves as a major instrument for public information and education by providing various types of exhibits, such as large temporary installation exhibits, mobile walk-throughs, and high school demonstration units for display throughout the country. These bring the progress in peacetime developments of atomic energy to large audiences at State, county, and local fairs, civic gatherings, and similar events, and to students at the elementary, high school, and college level. In addition, there is a special exhibits program to provide individualized exhibits for domestic technical and industrial conferences and trade fairs to familiarize industrial, scientific, engineering, and man-

agement personnel with Commission technical programs and developments. The following is a summary of the items under the activity:

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
American Museum of Atomic Energy	$131,231	$107,000	$107,000
AEC traveling exhibits program	469,725	500,000	493,000
Domestic industrial exhibits program	2,917	23,000	20,000
Total museum and exhibits	603,873	630,000	620,000

(*b*) *Publications and libraries, $2,455,000.*—The Commission's technical information program provides information materials and services to science and industry. In addition, the program implements agreements for international cooperation by furnishing technical information services under the atoms for peace and bilateral agreements programs.

The estimate of $2,455,000 covers activities necessary to fill the needs of the AEC and its contractors, and the needs of science and industry generally for scientific and technical information materials originated within the AEC program. These include the maintenance of classified depository libraries for use by access permit holders, preparation under contract of unclassified books compiling technical data essential for peacetime applications of atomic energy, the writing under contract of a series of unclassified technical progress reviews to keep industry abreast of current technical developments in the atomic energy field, the translation of technical data from Russian and other foreign language materials, the printing of materials published and distributed under the industrial participation activities of the Commission, and the conduct of a survey and analysis of methods for the dissemination of technical information as a basis for evaluating the desirability of adopting improved methods. The estimate also covers all costs in connection with the operation of the Technical Information Service Extension at Oak Ridge for providing (*a*) both classified and unclassified central AEC publishing, reference, abstracting, document collection and distribution services; (*b*) both classified and unclassified technical information services to the Commission's access permit holders under the civilian applications program; and (*c*) primarily unclassified technical information services to domestic depository and educational libraries and to libraries established in foreign countries under the atoms for peace and bilateral agreements programs. The following is a summary of the items under this activity:

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Classified depository libraries	$9,453	$20,000	$20,000
Technical books program	499,038	295,000	295,000
Technical progress reviews	72,214	136,000	136,000
Translations program	40,000	100,000	120,000
Printing	35,034	160,000	193,000
Technical Information Service Extension, Oak Ridge	1,614,519	1,501,000	1,651,000
Personal services	957,212	1,040,000	1,056,000
Travel	6,544	6,000	6,000
Other objects	651,663	455,000	589,000
Other	0	55,000	40,000
Total publications and libraries	2,270,258	2,267,000	2,455,000

(*c*) *Equipment not included in construction projects, $40,000.*—The estimate provides for additions and replacements of office furniture, machines, and printing equipment in connection with the technical information program. There

follows a breakdown of equipment costs indicating amounts estimated for each contractor in relationship to other operating costs under this program:

Installation	Other operating costs	Equipment costs
Oak Ridge Institute of Nuclear Studies:		
American Museum of Atomic Energy and AEC traveling exhibits program	$600,000	$9,000
Technical Information Service Extension, Oak Ridge	1,651,000	31,000
All other	824,000	0
Total	3,075,000	40,000

5. International conferences, exhibits, and studies, $1,150,000

The training, education, and information program costs estimated for fiscal year 1960 under this category include the support of specialized nuclear topical conferences of interest to the scientific community and the organization and presentation of oversea nuclear energy exhibits.

Summary of estimates by activity

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
International conferences, exhibits, and studies:			
(a) Special conference	$1,853,388	$2,500,000	0
(b) Topical conference	31,536	75,000	$150,000
(c) Overseas nuclear energy exhibits	246,494	500,000	1,000,000
Total international conferences exhibits, and studies	2,131,418	3,075,000	1,150,000

The Second International Conference on the Peaceful Uses of Atomic Energy was held in Geneva, Switzerland, September 1 through 15, 1958. All costs related to this conference will be completed in fiscal year 1959; hence, no funding will be required in fiscal year 1960.

Under the topical conference program the Commission grants partial or full financial support to a selected number of international conferences and symposia convened to examine specialized scientific subjects related to atomic energy. Financial assistance to international conferences is used to defray conference expenses which include travel of selected foreign and U.S. scientists, a reasonable share of costs related to publishing the proceedings of the conference, and expenses for secretarial assistance.

The estimate for fiscal year 1960 of $150,000 is based on the assumption that the Commission will support at least 15 conferences at an average cost of $10,000 per conference. Actual experience in fiscal year 1958 indicates that of the seven conferences supported, the average cost per conference was $11,000. During the first half of fiscal 1959, 16 proposals or inquiries regarding financial support were received. It is anticipated that at least 10 to 15 conferences will meet the criteria of this program and will be supported by the Commission in fiscal year 1960.

The fiscal year 1960 estimate of $1 million for international nuclear energy exhibits is based on the assumption that four exhibits will be held in this period. Past experience indicates that the cost of an exhibit varies according to its size, complexity, and location with the average approximating $250,000. The Rome exhibit held in fiscal year 1958 cost approximately $250,000, while budget plans for the Tokyo exhibit to be held in May 1959 approximate $400,000. The estimated cost of an exhibit provides for the cost of design, fabrication, transportation, operation, and dismantling of the exhibit.

On the basis of a survey conducted by the AEC, the Department of State and a selected group of U.S. embassies, recommendations were received for holding nuclear energy exhibits in Australia, India, Spain, Pakistan, and Egypt. Final determination and selection of exhibit locations in fiscal year 1960 will be made upon the approval of the Commission in conjunction with the Department of State.

ACTIVITY COMPARISON WITH 1959 BUDGET

Mr. CANNON. The activity breakdown under this heading has been rearranged. In order that we can compare this with last year's arrangement we should be glad to have you insert comparable tables so that we can understand how the 1959 funds are being used.

(The information follows:)

TRAINING, EDUCATION AND INFORMATION PROGRAM—COST DISTRIBUTION IN TERMS OF THE CATEGORIES AND ACTIVITIES SHOWN IN THE 1959 JUSTIFICATION

Operating expenses

[In thousands]

Category and activity	Fiscal year 1958, actual	Fiscal year 1959, estimate	Fiscal year 1960, estimate
1. Operation of schools	$1,473	$1,584	$2,136
(a) I.I.N.S. & E	735	645	780
(b) ORSORT	380	100	0
(c) ORINS	231	202	256
(1) Special training program (Radio)	(231)	(202)	(256)
(d) Puerto Rico nuclear center	127	425	745
(e) Monitoring techniques course (HASL)	0	12	15
(f) Shippingport supervisors course	0	100	200
(g) Reactor hazards and supervisors course	0	100	140
2. Fellowships	620	854	1,210
(a) Nuclear science and engineering	248	375	550
(b) Radiological physics	259	334	460
(c) Industrial hygiene	27	45	50
(d) Industrial medicine	86	100	100
(e) Advanced graduate studies (radiological physics)	0	0	50
3. Assistance to schools	7,493	4,462	6,169
(a) Training equipment and assistance	6,565	3,365	4,200
(1) Reactor training equipment	5,400	2,265	3,100
(2) Life sciences training equipment—life sciences	1,165	1,100	1,100
(b) Development of pedagogical tools	97	50	0
(c) Faculty training	831	1,047	1,969
(1) Radiobiology training for high school teachers	314	450	600
(2) Radiobiology lecture series	0	10	10
(3) Summer institutes for engineering faculty	329	300	350
(4) Research participation program in reactor technology	37	50	100
(5) Radiobiology training for college faculty	0	70	159
(6) Advanced radioisotope training—medical	0	0	50
(d) Nuclear materials and services	151	167	700
4. International conferences, exhibits, studies and other assistance	2,281	3,175	1,350
(a) Special conferences	1,853	2,500	0
(b) Topical conferences	32	75	150
(c) Country program studies	149	100	200
(d) Overseas nuclear energy exhibits	247	500	1,000
5. Museum and exhibits	604	630	620
(a) American Museum of Atomic Energy	131	107	107
(b) AEC traveling exhibits program	470	500	493
(c) Industrial exhibits program, headquarters	3	23	20

Operating expenses—Continued

[In thousands]

Category and activity	Fiscal year 1958, actual	Fiscal year 1959, estimate	Fiscal year 1960, estimate
6. Publications and libraries	$2,270	$2,267	$2,455
(*a*) Classified depository libraries	9	20	20
(*b*) Technical books program	499	295	295
(*c*) Technical progress reviews	72	136	136
(*d*) Translation program	40	100	120
(*e*) Printing for industrial information program	35	160	193
(*f*) Technical Information Services Extension, Oak Ridge	1,615	1,501	1,651
(*g*) Other (DIS)	0	55	40
7. Other TE & I activities	312	331	465
(*a*) Division of B. & M. program	156	181	265
(*b*) Division of Reactor Development Program	156	150	200
8. Equipment	401	397	395
(*a*) Information services	37	33	40
(*b*) Puerto Rico Nuclear Center	318	318	305
(*c*) Biology and medicine	46	46	50
Grand total by division	15,454	13,700	14,800
Reactor development	6,798	3,557	5,200
Biology and medicine	2,284	2,538	3,150
International affairs	1,329	1,600	2,185
Information services	2,911	2,930	3,115
Special projects	2,132	3,075	1,150

SHIPPINGPORT REACTOR TRAINING SCHOOL

Mr. CANNON. For example, no reference was made to the Shippingport Reactor Training School last year but you are spending $100,000 for 1959, and you are requesting $200,000 for it in 1960.

On what basis do you decide to take off on a program like this without any budget proposal to the Congress?

Dr. PITTMAN. Mr. Chairman, the funds for the Shippingport School were included in the budget which was presented last year. It was not defined as such because at the time that the budget was submitted the plans for the school had not been firmly enough established to say that this is exactly what was to be done.

Mr. CANNON. I do not recall any discussion about it at all last year. In fact, it takes me by surprise.

Dr. PITTMAN. I will have to ask somebody who was present last year about the discussion because I was not here. I know provision had been made for that kind of a teaching and training course in the budget, and I must say I was not here so I do not know about the discussion at the committee hearing itself.

Mr. CANNON. The school was organized this last year, then, in the current year?

Dr. PITTMAN. The first course was started in February of this past year with 23 or 24 students taking the course now.

Mr. CANNON. How are students selected? What qualifications are required?

Dr. PITTMAN. The purpose of the course——

Mr. CANNON. It is in the nature of a refresher course?

Dr. PITTMAN. It is more in the nature of a course for the supervision that is to be used in the power reactors and the reactors that are springing up around the country. It is the only large-scale operating reactor where this kind of training, on-the-job training, can be given. It is a very valuable tool to those people such as Consolidated Edison and the Yankee groups.

Mr. CANNON. You bring in students from the outside?

Dr. PITTMAN. Yes, sir.

Mr. CANNON. You are not dealing with your own staff?

Dr. PITTMAN. No, sir. This is not for the staff of the Commission. This is for people outside.

Mr. CANNON. Is it done on application from corporations or application from individuals?

Dr. PITTMAN. It is done on application from the corporations and from the companies to send send people.

For instance, this year in attendance there are representatives of Philadelphia Electric, Yankee Consolidated, Northern States, and so on. I can list all of the groups.

There are also four foreign countries represented—Italy, Japan, Taiwan, and India.

The individual students, or companies for them, pay fees of $2,000 per person for the course.

If I understand the budgeting situation correctly, the $200,000 that we have in for 1960 has an offset, assuming we get the 100 students during the year that we think we will get.

Mr. CANNON. Is tuition uniform for those people from abroad?

Dr. PITTMAN. It is the same as for American corporations.

Mr. CANNON. $2,000?

Dr. PITTMAN. That is right, sir.

Mr. CANNON. You do not include any of your own personnel?

Dr. PITTMAN. No, sir. This is for training of the people who are actually going to be supervising operating reactors. It is the only possible way they can get this kind of training.

It does have some book training, too, because we want to be sure the people are capable and knowledgeable in the field of safety particularly.

I think you heard Admiral Rickover discuss this whole problem, the importance of training.

This is run at the Shippingport reactor and he has a great interest in this course. It is to develop not only the ability to handle the control systems but also the knowledge of what to do under all sorts of conditions.

It is for supervisory personnel in these schools and it is not for people in the AEC.

Mr. CANNON. I cannot imagine anything that would be more important or anything that would have further reaching advantage, but it is a service to the corporations who send students here to be trained.

Could not the tuition be sufficient to cover this cost without the Government providing this $200,000?

Dr. PITTMAN. The tuition is at a level that will make the course self-liquidating and there is an offset of $200,000 at another part of the budget to take care of that.

It is supposed to be sufficient to cover the cost.

Mr. CANNON. It is self-sustaining, then?

Dr. PITTMAN. Yes, sir. It has not been self-sustaining as yet in 1959 because we just have gotten it started and it takes some time to get the people in.

Mr. CANNON. Up to this time your students have been interested in the course and have completed the course assigned to them?

Dr. PITTMAN. No, sir. The first course, which started on February 9, has not yet ended. It is still going on.

Mr. CANNON. No students are dropping out?

Dr. PITTMAN. I cannot answer that question about whether or not they are dropping out. I know there has been an extreme interest on the part of the companies who recognize this as the most valuable training ground for the type of training they want.

We are working very closely with Admiral Rickover in trying to develop the best possible training course to take into account the fact that is an operating reactor and therefore you have to fit the training into the operational and developmental needs.

We are working very closely with him. Courses are about 6 months.

Mr. CANNON. What are the requirements to matriculate? Do you require a bachelor's degree from a standard school or university?

Dr. PITTMAN. For the courses we are giving now, for the supervisory personnel, it is necessary to have a B.S. I am not sure whether it is in engineering, but they have to have a scientific background.

I have received a note that no students have dropped out of this 6-month course.

Mr. CANNON. Is it likely that you will change the character of the course during the coming year?

Dr. PITTMAN. It is quite likely it will change. We are trying to feel our way as to the relationship between the book work, the classroom work, and the actual work in the reactor itself.

Another factor that is coming up is the extent to which the students are allowed to participate during the maintenance and the period when the reactor is down because it is then that the students themselves can learn the most about the reactor and how it is put together, but it also is most difficult to work students into an operating organization, so we have this balance to make.

I am quite sure during the next course and the courses to follow there will be changes, I hope always for the better, in this training program at Shippingport.

FEES FOR MUSEUMS AND SPECIAL EXHIBITS

Mr. CANNON. Last year we discussed with you the elimination of fees being charged for museums and special exhibits. I believe the Committee issued a directive in which we asked you to abolish such fees and make such admissions to museums and exhibits free.

Has that been done?

Dr. PITTMAN. That is in another part of the program, sir.

Mr. MCCARTHY. That is right. Last year Oak Ridge was mentioned. There is no fee charged for the Oak Ridge Museum.

Mr. CANNON. That is an entirely different matter. The museums and exhibits have no direct connection with your schools.

Dr. PITTMAN. That is right. That is why I could not answer the question, sir.

INTERNATIONAL EXHIBITS

Mr. CANNON. Last year you spoke about international exhibits for which you were asking $1½ million.

I notice you show on page 204 that you will spend only about $500,000 this year. How is that $1½ million being spent and did we provide $1 million too much?

Mr. GARDNER. The reason $500,000 alone was spent in fiscal year 1959 is because the International Conference at Geneva took place during the same year. There was not enough time to have the two or three additional exhibits that we had expected to have.

This $500,000 takes care of an exhibit which just recently was completed in Tokyo for about $400,000.

Mr. CANNON. $400,000?

Mr. GARDNER. Yes, and for an advance on an exhibit in which the Atomic Energy Commission will take part in New Delhi at the end of this calendar year.

Mr. CANNON. These exhibits, I take for granted, are both educational and informative. They are also in the nature of propaganda. They are selling America, American industry, and American science to the world.

What is the primary purpose?

Mr. GARDNER. The primary purpose is to show to the world the state of our scientific advancement. This we did at Geneva in a rather spectacular show. I think the world admits we were far ahead of the Russians in our state of development.

Further, there is one addition aspect we have been able to take care of, and that is to install operating reactors in these exhibits which help allay the fears of other people as to the peaceful uses of atomic energy.

Mr. CANNON. What is the duration of these exhibits? Is it for one season or 1 year?

Mr. GARDNER. The exhibit in Geneva, 2 weeks; the one in Tokyo a little over 2 weeks.

The one scheduled for New Delhi will be a little over 2 months.

These vary in time according to the directives of the exhibit.

Mr. CANNON. They attracted enough attention to compensate us for the investment?

Mr. GARDNER. Indeed, sir.

Mr. CANNON. They attracted favorable comment or was there criticism?

Mr. GARDNER. We never have had criticism of any exhibit we have shown yet, sir.

Mr. CANNON. Those accounts have been closed?

Mr. GARDNER. Yes, sir.

Mr. CANNON. You are asking $1 million for the coming year?

Mr. GARDNER. Yes, sir.

Mr. CANNON. How do you expect to spend that?

Mr. GARDNER. We plan to have at least two exhibits in the fiscal year 1960 and plan for two more.

The long leadtime that is required requires funds with which we can operate in the planning and the operation of exhibits.

Mr. CANNON. Last year the request was for $2,200,000. In the end, however, when you came to spend the money, you spent only $400,000.

If your entire investment last year was $400,000 for the one exhibit how can you spend $1 million this year?

Mr. GARDNER. Last year the request for funds for exhibits included the Geneva exhibits which have been completed, For fiscal year 1960, we are planning on two exhibits, one in New Delhi which is estimated at $350,000, of which a little will be expended from 1959 funds and the remainder out of fiscal 1960 funds; another exhibit will be planned for the spring of 1960. There will be advance planning for one or two more which are scheduled——

Mr. CANNON. Where did you say it was?

Mr. GARDNER. I did not say. It is being planned.

We have requests now from 11 different embassies for exhibits, and one other——

Mr. CANNON. You do not expect to allow them all?

Mr. GARDNER. Probably we will not be actually able to mount more than two full-blown exhibits a year.

Mr. CANNON. Where will they be located?

Mr. GARDNER. One will be in New Delhi. This is firm.

Mr. CANNON. Was that the location of one of your exhibits this year?

Mr. GARDNER. This is the start. We were planning in 1959 for it. It will actually take place in December 1959, January and February of 1960.

The other one has not been selected as yet because we are still discussing with the Department of State the best location for an exhibit.

Mr. CANNON. It would not be in the same area. It will not be in the Orient, will it?

Mr. GARDNER. The second one might possibly be in the Middle East.

Mr. CANNON. They are placed largely among neutral nations?

Mr. GARDNER. Yes, sir.

Mr. CANNON. You have had 11 requests?

Mr. GARDNER. Yes, sir.

Mr. CANNON. Official requests?

Mr. GARDNER. These are indications from the embassies that they wished exhibits.

Mr. CANNON. What nations?

Mr. GARDNER. Australia, Greece, Lebanon, Italy, Korea, Formosa, the Chinese Nationalists, Pakistan, Egypt, Spain, Iran, and India, of which one will go in New Delhi.

In addition, we have had a request from the Department of State to have a mobile exhibit for Latin America which may visit three, four, or five countries.

Mr. CANNON. Off the record.

(Discussion held off the record.)

Mr. CANNON. Further questions on this item?

Mr. JENSEN. I have just a few questions.

Mr. CANNON. Mr. Jensen.

FOREIGN STUDENTS AT SHIPPINGPORT SCHOOL

Mr. JENSEN. Going back to the students who are attending the Shippingport School—are there foreign students at Shippingport now taking this course?

Dr. PITTMAN. Yes, sir.

Mr. JENSEN. From what nation do they come?

Dr. PITTMAN. Four of them, sir. I remember India, Italy, Japan, Taiwan.

Mr. JENSEN. Off the record.

(Discussion held off the record.)

Mr. JENSEN. This school has been in operation how long?

Dr. PITTMAN. Since February 9 of this year.

Mr. JENSEN. Are you receiving more applications now than the limit?

Dr. PITTMAN. We can take only 50 in 1 class. If I may supply for the record the number we have applying for the second class I will be glad to do it. I do not have the figure of applications.

(The information referred to follows:)

Sixteen students have applied for admission to the second class.

Dr. PITTMAN. I do know there is an extreme interest in the course and there are people from all of these reactor groups who want to come into it.

Mr. JENSEN. Without a doubt there are many students who would like to take this course who do not have the finances to put up, because $2,000 is a lot of money for many people.

Are the companies making any provision to help these students?

Dr. PITTMAN. If you recall, sir, the purpose of this course is to train the supervisory people, generally, for specific jobs, jobs in specific reactors, and most of our people are coming from companies who have reactors under construction.

It is not the kind of thing that would be something an individual would take just to get training in nuclear science. The companies pay the tuition. No individual student pays for this.

Mr. MCCONE. You are training operating managers and operating superintendents who develop a degree of competence so they can operate these reactors we have been talking about that are under construction and soon ready for operation.

Mr. CANNON. Is the tuition paid by the company?

Dr. PITTMAN. That is right, sir.

Mr. CANNON. And probably they also continue his salary while he is taking the course?

Dr. PITTMAN. He is on the payroll of the company. He is assigned there for this job. His tuition is paid.

As an example, Consolidated Edison has sent five people to this first course. They pay the tuition.

Mr. JENSEN. I am sure it is a very worthwhile course.

How many dollars are we spending for scholarships in this bill?

FELLOWSHIP PROGRAM

Mr. MCCARTHY. Fellowships in 1960 are estimated at $1,210,000 throughout the training and education program.

Mr. JENSEN. You have no trouble finding enough students for these fellowships, I assume?

Mr. MCCARTHY. No, sir. I am pretty sure in all of the various disciplines we have adequate candidates.

Mr. JENSEN. It is surprising, when you talk to these young Americans, even down to those 12 years old, to learn how well informed they are on this atomic age of ours. They read everything they can get hold of to prepare them for this great atomic age we are in.

(Discussion held off the record.)

Mr. CANNON. Are there further questions on this section?

Mr. FENTON. You say the industrialists pay for the tuition of the people they want to go to this school. What about the foreign students? Who pays for them?

Dr. PITTMAN. I am sorry, but I do not know exactly who pays. We do not pay for it.

Mr. MCCARTHY. Either the foreign countries, or the company they work for in the foreign country.

Dr. PITTMAN. I believe it is the country. We will supply that for the record.

(The information requested follows:)

NUCLEAR POWER STATION TRAINING PROGRAM AT SHIPPINGPORT TUITION PAYMENTS FOR FOREIGN ATTENDANTS

Chia Shi Lin	Taiwan Power Co.
Nariaki Goto	Kansai Electric Power Co.
Salvatore De Meis	CAMEN.
Githal Kothare (India)	International Cooperation Administration.

CIVILIAN APPLICATION OF ISOTOPES AND NUCLEAR EXPLOSIVES

Mr. CANNON. We shall now take up the civilian application of isotopes and nuclear explosives for which $14,100,000 is asked.

I shall ask that you include pages 206 through 212 in the record.

(The material referred to follows:)

CIVILIAN APPLICATIONS OF ISOTOPES AND NUCLEAR EXPLOSIVES—OPERATING COSTS

Program statement

Estimate, fiscal year 1960	$14,100,000
Estimate, fiscal year 1959	5,700,000
Increase	8,400,000

Two major programs are included under the above heading: (1) the development of industrial uses of radioisotopes and radiation, and (2) the development of civilian applications of nuclear explosives ("Plowshare"). A summary of the budget estimates for these two programs follows:

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Isotopes development program	$44,104	$3,000,000	$6,100,000
Plowshare program	326,205	2,700,000	8,000,000
Total	370,309	5,700,000	14,100,000

The isotopes development program in fiscal year 1960 will extend exploratory research and development activities initiated during fiscal year 1959. A broadening of the program is planned to accelerate realization of the potentially vast nonpower uses of atomic energy. This program, primarily of an applied research and development nature, has four phases which are integrated to provide balance to the program. These phases are aimed toward: (1) expanding the technology and utilization of isotopes with particular attention to industrial and commercial opportunities; (2) laying the foundation for large-scale training of persons who can work safely with radiation; (3) encouraging private production of isotopes in anticipation of the time when private industry will supply a major portion of all radioisotopes; and (4) developing through research and development activities applications of high-level or massive radiation.

The Plowshare program provides for the development of the peaceful uses of nuclear explosives including research, development, and testing of devices for specific applications. The primary effort in fiscal year 1960 will be: (1) to expand the theoretical studies and research effort on all phases; (2) to continue research toward the design and development of industrial prototype devices; (3) to investigate applications relative to the recovery of oil; (4) experiments to obtain data applicable to the use of nuclear explosives for excavation purposes; and (5) experimental effort directed toward power and isotope production. The participation of private industry in this program will continue to be encouraged. The primary responsibility for the conduct of the technical aspects of this program rests with the Lawrence Radiation Laboratory at Livermore, Calif.

Summary of estimates by category

Category	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
1. Isotopes development program:			
(a) Radioisotope application development	0	$1,300,000	$3,250,000
(b) Radioisotope technology training	$11,412	750,000	1,100,000
(c) Radioisotope production process development	14,281	400,000	790,000
(d) Industrial process radiation	18,411	550,000	800,000
(e) Equipment not included in construction projects	0	0	160,000
Total isotopes development program	44,104	3,000,000	6,100,000

JUSTIFICATION OF CATEGORIES

(*a*) *Radioisotope application development, $3,250,000.*—Activities in this category are directed toward development of practical industrial uses of radioisotopes and represent an acceleration of the program initiated in fiscal year 1959. This intensification will be accomplished through research and development contracts with universities, research laboratories, and industrial organizations directed toward the identification, development, and extension of radioisotope technology to new areas of application. Participating organizations will be responsible for initiating, developing, and carrying out projects, with the AEC providing technical assistance. Areas of development having the greatest technological impact on broad segments of industry will be selected. Examples of such areas include industrial process control using tracer techniques, neutron gages for measurement of contaminants or constituents of products, beta and gamma ray gages for measurement of thin-sheet materials, neutron activation techniques for meeting rigid material requirements, and more sensitive test methods that assure product quality measured against improved standards.

Integrated process control systems utilizing radioisotopes in manufacturing operations will result in significant technological progress and yield great economic benefit to the national economy. The availability of discrete types and energies of radiation, coupled with advances in electronics and servomechanisms, will permit transduction of analytical radiation beams to automatically regulate production processes in a manner far superior to most other control systems. This intensified mechanization is a new technology requiring considerable engineering development for adaptation to specific problem areas.

Broad programs for development of fundamental applications technology will be initiated. Thise programs will be established at universities and colleges having established nuclear energy programs, and will be designed to draw upon

the unique technical resources in the many scientific disciplines available within a university framework.

The increase in this category results from broadening the scope of activities to include newly developed concepts and devices, identification of additional problem areas amenable to improvement through application of radioisotope techniques, and more intensive effort on fundamental applications research.

(*b*) *Radioisotope technology training, $1,100,000.*—The activities under this category are directed toward presentation of a balanced program to: (*a*) Provide specific lecture and laboratory instruction to practicing engineers and scientists in the industrial applications of radioisotopes, and (*b*) integrate isotope applications technology into engineering and physical science curricula in American colleges and universities.

The basic training course in the industrial applications of radioisotopes initiated in fiscal year 1959 at the Oak Ridge Institute of Nuclear Studies will be continued, offering regularly scheduled courses designed to meet industrial needs for both basic and specialized radioisotope training.

Undergradute and postgraduate instruction in radioisotopes and radiation technology will continue to be supported through the provision of equipment grants required for lecture demonstrations and laboratory facilities—a necessary adjunct to classroom uses of radioisotopes and radiation. In addition, initial efforts will be made to encourage the training of isotope technicians through assistance to technical institutes which emphasize instruction in engineering or scientific subjects to a semiprofessional degree. A new activity directed toward the provision of institute training to college faculty and industrial personnel will be initiated. Intensive courses will be scheduled on regional bases in cooperation with selected educational organizations.

(*c*) *Radioisotope production and process development, $790,000.*—This category is directed toward creating the technological basis and market conditions required for ultimate transition from government to private production of radioisotopes and involves research and development activities in the following areas: (*a*) Fabrication of radiation sources such as cobalt 60, cesium 137, and gross fission products, (*b*) new production items such as radioactive rare earths and (*c*) reactor and chemical process facilities for isotope production. Increases in fiscal year 1960 reflect the availability of large cobalt 60 sources and increased quantities of separated fission byproducts necessary for implementation of radiation source development objectives. Development of new production items and design studies on isotope production facilities will reflect greater emphasis on specific projects derived from the analyses of fiscal year 1959.

Isotope process development activities are concerned with the development and improvement of chemical processes and equipment for the separation and purification of radioisotopes, the development of new radioisotope products, and investigation of uses of radiation. The program includes development activities in the separation of both neutron-produced and fission product radioisotopes, the development of radiation source units, the design of process equipment, and the utilization of radioisotopes.

(*d*) *Industrial process radiation, $800,000.*—Activities under this category are designed to define and develop the technology required for beneficially employing in the national economy the vast reservoir of radiation power resulting from atomic energy development. Exploratory activities are directed toward the definition of specific research and development projects. These will encompass radiation source technology, efficiency, and utilization studies at BNL and high-level radiation applications research and development contracts with industrial firms and research institutes.

(*e*) *Equipment not included in construction projects, $160,000.*—$20,000 is required at the Oak Ridge Institute of Nuclear Studies for the purchase of specialized laboratory equipment to be used in conjunction with the basic course on industrial utilization of radioisotopes. $140,000 is required for the purchase of equipment to maintain the AEC's isotope production program. Following is a summary of operating costs and related equipment costs for fiscal year 1960:

Contractor	Other operating costs	Equipment costs
ORINS	$50,000	$20,000
All other	5,890,000	140,000
Total	5,940,000	160,000

Summary of estimates by category

Category	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
2. Plowshare program:			
(a) Research and development	$326,205	$1,000,000	$2,500,000
(b) Industrial feasibility experiments	0	1,400,000	5,000,000
(c) Equipment not included in construction projects	0	300,000	500,000
Total Plowshare program	326,205	2,700,000	8,000,000

JUSTIFICATION OF CATEGORIES

(*a*) *Research and development, $2,500,000.*—The estimate under this category is required to provide the research effort necessary for the orderly development of the Plowshare program. The research program now planned for fiscal year 1960 includes feasibility studies of new areas where nuclear explosives may have beneficial application, laboratory support for field experiments, design, and development of special instrumentation, and development of devices for Plowshare uses.

Research effort will be directed toward the problems of instrumentation and nuclear device design which are unique to the Plowshare program. Much addition work is needed to provide accurate measurement of certain effects associated with a contained explosion, such as temperature history and pressure buildup. Likewise, study must be given to device design for specific application. Studies will continue to determine the possible application of nuclear explosives in yet unexplored areas.

In order to provide the maximum assurance that an experiment will be successful and to obtain the maximum scientific data furnished by the experiments. extensive before and after project analysis is essential. This effort encompasses such activities as the study of thermoconductivity of containment media, predicting the nature of the cavity to be created and forecasting the effects of seismic shock and elastic waves in various media.

(*b*) *Industrial feasibility experiments, $5,000,000.*—The activities included in this category are designed to demonstrate the peaceful applications of nuclear explosives. During fiscal year 1959, work was begun on civil engineering projects and on a power and isotopes production experiment—Project Gnome. The fiscal year 1960 budget provides for a continuation of these projects and the commencement of work on an experiment designed to recover oil from shale and preliminary work on recovering oil from tar sands.

The civil engineering projects are planned as experiments to obtain engineering and scientific information applicable to the use of nuclear explosives for purposes such as harbor and canal excavation. These projects will provide valuable data on scaling laws, multiple and simultaneous detonations, the relation of depth of burial to surface effects and biological effects.

In the Project Gnome experiment, it is proposed to detonate a nuclear device in the range of 10-kiloton yield in the salt bed in the Carlsbad area of southeastern New Mexico. The experiment is designed to provide information on the possibility of generating useful power, utilizing the heat released from such a detonation, and the production and recovery of isotopes, which in principle can be produced by the neutrons from a contained nuclear explosion.

The Green River formation (in Colorado, Utah, and Wyoming) is the most likely site for the oil shale project which will be conducted to determine if oil shale can be broken in sufficient quantities and to proper size to permit oil recovery. The cost of the project is expected to be shared jointly by AEC, Bureau of Mines, and the petroleum industry.

(*c*) *Equipment not included in construction projects, $500,000.*—Expansion of the research program and the conduct of field experiments in the budget year will increase equipment requirements for laboratory use and necessitate the acquisition of firing trailers, and communications and instrumentation equipment.

Following is a summary of operating costs and related equipment costs for fiscal year 1960.

Contractor	Other operating costs	Equipment costs
Lawrence Radiation Laboratory	$4,000,000	$200,000
All other	3,500,000	300,000
Total	7,500,000	500,000

NEED FOR PROGRAM EXPANSION

Mr. CANNON. During an orientation session we heard glowing statistics about the widespread and growing use of isotopes. Why is it necessary to increase this development program from $3 million to $6,100,000 if it is already being taken up on such a broad front by industry and private research organizations?

Mr. MCCONE. Dr. Aebersold will respond to that.

Dr. AEBERSOLD. Actually, there are many industries that have not made much use of radioisotopes to date. For example, coal, textiles, pharmaceuticals, gas, soaps, and detergents, food processing, and so forth. The fiscal year 1959 costs are just our first year effort in which we made largely exploratory activities, for example evaluation of the many under-developed potentials for isotopes and radiation. Also we are just beginning to explore new technology.

Radiation energy for example has been only explored thus far as a processing tool for processing chemicals, plastics, rubber, and so on. We had a study made by contract, and this large volume [indicating] is just one report on potentials for radiation energy. It is called "Radiation, a Tool for Industry," by Arthur D. Little, Inc. This company's experts explored this whole field of uses for large quantities, high energy levels of radiation. It points out that most of the uses are undeveloped. The same is true of the usage of low levels of isotopes in segments of industry such as coal, textiles, cement, ceramics, glass, rubber, steel, transportation, and so forth.

As far as preliminary studies have gone, we are finding scores of undeveloped uses in every one of these fields. Much development effort is therefore required.

The isotopes development program has had a great response from industry, and education and research institutions. We could only announce our program 9 months ago after we received our appropriation, yet we have already received 180 development proposals totaling $10 million. With this year's funds we have only been able to contract for 60 of these development proposals totaling about $3 million. We are thus forced to deny two-thirds of the projects that are being proposed, and most of these proposed isotope developments look fairly good to us.

Even if we are appropriated the requested $6.1 million, at the rate good proposals are being received we think we will still be in the position of having to deny two-thirds of the proposed work.

With regard to the response from educational institutions for equipment grants and assistance to teach the handling and uses of isotopes and radiation, although such assistance was announced only 6 months ago, over 650 inquiries were received on training grant proposals. In

only 6 months formal proposals were submitted by over 70 schools totaling $2 million. With this year's funds we could only authorize 33, less than one-half of those received. At the rate that isotope training proposals are coming in we feel that we will have to deny two-thirds of the proposals, even if we receive the amount in our new budget.

Mr. CANNON. It seems to be growing, it seems to be spreading, and it seems to be increasingly recognized. You spent last year $44,104. You are spending this year $3 million. That is quite a jump. In the coming year you propose to spend $6,100,000. That is a further jump. Your sales on these have risen. You propose to sell during the coming year $3 million worth. Is this self-sustaining?

Dr. AEBERSOLD. Sir, the sales of radioisotopes are self-sustaining. What we are proposing in this budget is developing new uses and extending present uses into areas where they have not reached their potential, also developing a whole new field of using radiation as a processing tool. So this program is to develop whole new areas of use. The sales of isotopes, however, recover their own costs.

POSSIBILITY OF PROGRAM BEING SELF-SUSTAINING

Mr. CANNON. We have established the importance of the isotope and its use continues to grow. Have we not reached the point now where we can quit wet-nursing it and where we can leave it on its own for a while?

Dr. AEBERSOLD. I do not think this is a wet-nursing program. We are not subsidizing individual firms to develop something only of interest to themselves. We are doing development work that is of wide interest to industry. Isotope development projects are unclassified, the results are published, and they will be of value to many companies. These projects are ones we feel will have economic benefits to industry, bringing us more income, greater national productivity. We believe that the taxes alone on the increased industrial income will more than pay for our isotope development program. If so, I think our program is self-sustaining in the sense that the increased productivity that will result in industry is sufficient in millions of dollars to bring us more Government income from taxes than our proposed appropriation.

Mr. CANNON. They are by this time thoroughly indoctrinated. They are making wider use all the time of these, and they are sufficiently interested in them to come in here and pay us practically $3.5 million. Why can we not let them pay for the entire program? After we have reached this point where it should be self-sustaining why can't we let them take over the load?

Dr. AEBERSOLD. Part of this budget is also to bring out new isotopes, new products and isotope processing methods from Oak Ridge and Brookhaven.

Mr. CANNON. Which have not hitherto been introduced?

Dr. AEBERSOLD. Yes. This is the research and development on new forms of isotopes, new forms of radiation sources. In this case the budget is not for industry alone. Those developments are of wide interest to biology and medicine and research in general, and some of these important military uses, such as you saw, the isotope power source or "battery."

In regard to the radioisotope "battery." We are supporting part of this development for nonmilitary purposes, like Arctic weather stations and remote beacons for transportation, which are of much interest to other Government agencies.

EXTENT OF MATCHING FUNDS BY PRIVATE INDUSTRY

Mr. CANNON. To what extent are private industries matching Federal funds in the isotopes development program?

Dr. AEBERSOLD. There has been no real study of how much money they are spending, but I would estimate around $25 to $30 million a year is being spent on research and development on isotopes and radiation by private industry; in other words, they are spending five to six times more than we propose. I think our program has the value of being able to coordinate and develop new technology and long-range programs that are difficult for single private concerns to do.

Mr. CANNON. Quite a number of private institutions are taking this up and carrying it on and taking on their portion of the burden of research. There is the Massachusetts Institute of Technology at Cambridge, the University of Purdue in Indiana, the Rennssalaer Polytechnic Institute in New York, and the Research Institute at Durham, N.C. We are considering here funds for general research.

Dr. AEBERSOLD. Yes.

Mr. CANNON. Why shouldn't they carry this along on their own, or at least assume their share of the burden?

Dr. AEBERSOLD. Many of these are research institutions which are nonprofit. They have no way of making money, yet they do research and development of interest to industry in general. Even in the case of those private firms that have development contracts with us, they have a long background of doing work in this field. They have already invested a great deal of money in laboratory facilities and equipment. I think that in many ways they are more than matching our funds. For example, in terms of their own past efforts and what they have already invested in this field.

Mr. CANNON. They have their own laboratories, they have their own facilities, and they should be on their own feet. To what extent is private industry matching the Federal funds up to date?

Dr. AEBERSOLD. In these specific programs we have not asked for matching funds. There would be some problems of administration in this. But they have matched them in their past work. These people have a large background. Some have worked 10 or 15 years in this field. They are the ones that are discovering the new potential uses. I am not saying that industry would not do some of these things in time, but it might take many more years, 5, 10, or 20 years for some of these developments. The idea of this program is to bring forward the nonpower, peaceful uses of atomic energy much faster.

Mr. CANNON. How much of these funds for the current year are going to these educational institutions for research projects?

Dr. AEBERSOLD. I would say only about a fourth of them are going to educational institutions, but we do have an isotope training grant program for about $1 million worth of equipment to teach people how to use isotopes. These grants are going to educational institutions solely. We have had a tremendous response to this. Almost any school of any size can teach about isotopes and teach students

how to handle radiation. This is tremendously important to the Nation, to avoid fear of radiation. That can be done with only small grants of equipment, $5,000 to $10,000 worth, at most $80,000, whereas a program to train people in reactors may require expensive reactors. Required isotope training equipment is relatively inexpensive.

Mr. CANNON. I take for granted this is an applied research and development program, but why should grants be made to schools for abstract research?

Dr. AEBERSOLD. The abstract or basic research is supported by our divisions of physical sciences and the biology medicine people. Our program is more applied research.

Mr. CANNON. It is also done by these technical schools.

Dr. AEBERSOLD. All of these developments have some aim pointed at improving industry, improving industrial products, and industrial processes.

Mr. CANNON. Those are all for specific processes. The proposition here is for general and abstract research. This is supposed to be of practical use to industry, not the schools.

NUCLEAR EXPLOSIVES

Can these nuclear explosives ever be safely used for purposes for which conventional explosives are used today?

Mr. MCCONE. I would suggest, Mr. Chairman, that we ask Mr. Kelly to respond to that.

Mr. KELLY. Mr. Chairman, I must say, generally speaking, I do not believe nuclear explosives will replace conventional explosives, but only do those things that are too big, or too costly, or too time-consuming, or for some other reason one would not want to use conventional explosives.

Mr. CANNON. Of course, we have had all through this long discussion the question as to whether we will substitute nuclear weapons for conventional weapons. I suppose you have practically the same proposition in industry.

Mr. KELLY. Yes.

INDUSTRY COOPERATION

Mr. JENSEN. Do you feel, Mr. McCone, or anyone else, that private industry is properly cooperating in this field of isotopes, or do you feel that to some degree industry is dragging its feet and not putting in the effort in this field of isotopes to the degree that they should? I was interested in your response to Mr. Cannon. I can see, as everyone, that the Atomic Energy Commission has carried this research program on and the perfection of our isotopes in many fields is of great value to industry, including farming. I hope that you find no industry not willing to do their fair share in this field. If such an industry is found, I hope that you will report it to this committee, because certainly the Congress is not going to continue to appropriate these big sums without full cooperation by industry.

Would you like to elaborate on that just a bit more?

Dr. AEBERSOLD. Yes, Mr. Jensen. A great deal of the present uses of isotopes and radiation have been developed with private funds. There is a gap, however, between many things that are developed in our academic and national laboratories, between the many valuable

nuclear techniques developed in basic science and its practical applications. Sometimes the time may be 20, 30, or 40 years.

I will give you a good example—the mass spectograph. This was developed for sorting out atoms of different weights many years ago, almost 40 years ago. It has extensive practical application today for oil and chemical companies for analyzing hydrocarbons, for measuring different weights of molecules and other hydrocarbons. That has come about over a long period of time. It has been a slow development.

It is our feeling that many other nuclear techniques can be applied rather immediately to industrial problems. We feel that in the same way isotopes are proving useful in the health of the Nation they can also be good for the health of industry. I have been a medical physicist for 25 years, in which I have been more concerned with the use of isotopes in medicine, but only recently did we come to realize that the full potential of isotopes in industry is far from being realized. I have thus recently become more interested in the health of industry.

Mr. CANNON. Supplementing what Mr. Jensen has said, the laiety should bear their burden. For example, penicillin was discovered, not by a Government subsidized agency, but by a physician working by himself. One of the most effective specifics for the treatment of mental diseases and high blood pressure was known in India for 300 years and brought to America without the help of Government money. After the First World War they pooled all the patents to produce a Liberty motor and some fellow working in a barn somewhere developed the modern engine that took the place of what the experts had produced under Government subsidy. The laiety have their responsibility in this as well as the Government.

COOPERATION OF AGRICULTURAL EXPERIMENT STATIONS

Mr. JENSEN. Let me ask this: We have at Beltsville an experimental farm which, of course, has the responsibility of finding new uses for every kind of thing that would benefit agriculture. Do you find the Beltsville Experimental Station is cooperating? Are they developing any of these isotopes, or assisting you in any way?

Dr. AEBERSOLD. Yes. As I testified here in the proceedings before, every major agricultural experiment station in the United States is using isotopes for tracer studies of plant and animal diseases, to control weeds, insects, and so on. That amount of research we estimate is about $5 million a year in the agricultural field, and Beltsville is one of those doing this kind of work. It has been estimated that the return on this research—when the findings are made use of, such as how to use fertilizer better, and so on—will come back to be about $100 million worth of benefits to the agricultural field in general.

Mr. JENSEN. How many people at Beltsville are working with the Atomic Energy Commission in this field, would you say—half a dozen?

Dr. AEBERSOLD. We do not work directly with them. We cooperate in furnishing isotope materials and sources. I do not know whether we have a grant of actual financial assistance to other Government agencies in this type of work. Dr. Dunham would know.

Dr. DUNHAM. We are supporting some very fine work at Beltsville and have since the very beginning of our program. We assisted

the Department of Agriculture to get going by providing them with funds for the construction of a laboratory out of one of the early Atomic Energy Commission budgets. We had quite an active program both in soil chemistry using isotopes and in animal and plant physiology.

Mr. JENSEN. Agriculture being our basic industry, and knowing our wealth springs from Mother Earth, or is pumped out of the earth, or fished out of the seas, it becomes a very important matter to the continual growth of our economy. Farming today has become quite a scientific vocation.

Generally speaking, the farmer that does not operate on a scientific basis is lost forever. In this scientific age, and because of the fact that agriculture is basic to our entire economy, it is very natural one representing a farming district would be greatly interested in this matter. I am glad to know so much has been done with these isotopes in the field of crop production and other things as well. I naturally supposed that Beltsville would be working constantly with the Atomic Energy Commission and everyone else in this field. We have spent a lot of money to keep Beltsville going. They have a great responsibility to see that agriculture, and all new ideas that would benefit agriculture, are made known to the farmers of America. I hope that they will cooperate fully and completely in order to give the farmers of America the benefit of all their knowledge which is brought out by your commission and industry and others.

PLOWSHARE PROGRAM

Mr. CANNON. You are tremendously expanding what you term your plowshare program, the application of nuclear power to industry. From all that has been given us lately, largely in the international field, the days of aerial explosions are about over. The attendant danger is too great. The fallout is too deadly and we are about through with aerial explosions except where they are dictated by imminent military necessity.

You are increasing your program here from $2,700,000 to $8 million. I am wondering if you could ever use nuclear explosives for digging canals, crushing oil shale, and similar work without contamination that would be toxic to animal and vegetable life in the area. I should think the danger of contamination would be so great as to rather restrict your program here instead of warranting your quadrupling it. Isn't the danger of contamination, fallout, a factor to be taken into consideration in this plowshare program?

Mr. MCCONE. Well, Mr. Chairman, these tests can be conducted so that contamination, serious contamination, will not result.

Mr. JENSEN. By a clean bomb?

Mr. MCCONE. By relatively clean devices and by placement of the devices, and so forth. We feel that one of the great future uses in the peaceful uses of atomic energy is in the use of nuclear devices for explosives. I recently reviewed an estimate of a parallel to the Panama Canal. The difference in the cost of building that canal by conventional means and the estimated cost for building it, excavating it through nuclear devices, was in excess of $2 billion.

Granted, that is an estimate made by the laboratory. They can see the potentialities and possibilities of this use. I feel this is just one of the countless examples of how our country and this world can be benefited from this type of application of nuclear energy. We know something about it, and all we do know about it is really the result of nuclear weapons testing done in the environment close to the earth, either in Nevada or Eniwetok. The horizon here is very great.

A very important area, of course, will be underground where the results will be fully contained, but that is just one area of exploration. We have hopes, for instance, that nuclear devices might prove a means of releasing the oils in the Athabaska sands of northern Alberta. As you know, there are more proven oil reserves in the Athabaska sands in Alberta than there are in the Middle East. But it has defied the normals means of separating it from the sand. This is something the oil industry is looking at very seriously and is willing to put up a very substantial amount of their own money to prove this out.

Mr. CANNON. It would not be accompanied either in Canada or in Panama by deleterious results which would render that region uninhabitable?

Mr. MCCONE. No. However, we would move very slowly. Our plan would be first to experiment on a very small scale and in a very remote area and to be sure of our ground as we move forward. We are quite confident in the results, but we would not engage in any large operation that might have serious effects.

Mr. CANNON. In view of the hazard involved, would we not be warranted in slowing this increase? This current year you are using 2,700,000. For the coming year you are asking $8 million. In view of the hazard involved, don't you think we could cut that $8 million?

Mr. MCCONE. That $8 million was cut from, I think, $14 million or $15 million as requested by the laboratory. It represents a very austere amount for the program that the Livermore Laboratory planned to initiate and carry forward in fiscal 1960. I would urge that this committee allow this full amount.

With respect to the question of hazard, Mr. Chairman, there has been a great deal of evidence submitted to the Subcommittee on Hazards of the Joint Committee. Also, there have been extensive studies made by the United Nations Committee on Radiation. Fear has been created in the minds of people over this so-called fallout and the effects of it. The most informed people who have testified on this subject have concluded—and I think persuasively—that all of the weapons tests that have been made to date by this country and by the Soviets and by the British have not created a radiation hazard that offers serious consequences to people.

Mr. CANNON. You know Mr. Chairman, many are predicting confidently there will never be another world war because, as they say, it would amount to suicide for the nations involved.

Because of the uncertainty, don't you think we could reduce this? You have asked for a tremendous increase here. To cut out one-fifth or one-sixth of it would not seriously discommode you, would it?

Mr. MCCONE. Yes, sir; in this regard, because this is an area in which we are moving forward with a confident hope that we are

going to develop here something in the peaceful uses of atomic energy that will be useful to the world comparable to, if not greater than, any other peaceful uses we have discussed.

I am very impressed with these possibilities and I would urge that this country in its interests and in its concern about the welfare of the world pursue this.

COMMUNITIES

Mr. CANNON. On your "Community program" you are asking for $16,792,000. We shall insert pages 213 through 225.

(The pages follow:)

COMMUNITY PROGRAM—OPERATING COSTS

Program statement

Estimate fiscal year 1960	$15,666,000
Estimate fiscal year 1959	16,792,000
Decrease	1,126,000

The "Community program" provides for operation and administration of AEC-operated communities, including municipal services, utilities, hospitals, housing, and commercial properties in the AEC controlled and operated communities of Oak Ridge, Tenn., Richland, Wash., and Los Alamos, N. Mex. These operations are carried out principally under the cost-type contracts. Commercial facilities are generally operated by private enterprise through lease or concession agreement. Housing and utilities are provided also for project-connected employees at Sandia, N. Mex., and Monticello, Utah.

The Commission is currently disposing of housing and commercial properties at Oak Ridge, Tenn., and Richland, Wash., in accordance with the community disposal legislation. The disposal schedules for real estate are based on the assumptions provided by the Housing and Home Finance Agency, the Agency assigned responsibility for the real estate disposal activities at Oak Ridge, Tenn., and Richland, Wash. Estimated disposal schedules included in the following pages reflect disposal of 91 percent of all property by the end of fiscal year 1959, and less than 1 percent remaining unsold at the end of fiscal year 1960, consisting of a few commercial and nonresidential properties.

The community disposal legislation provided for the communities of Richland, Wash., and Oak Ridge, Tenn., to incorporate and take over the responsibilities of self-government of the communities. The community of Richland, Wash., incorporated in December 1958. The community of Oak Ridge voted on May 6, 1959, to incorporate with election of city officials to be held on June 2, 1959. Since agreements have not been consummated with the local entities for the transfer of facilities (i.e., water, sewage, and electrical distribution systems, etc.), these budget estimates are based on the assumption of continued operation by the Commission of these facilities during fiscal year 1960. In the event that any transfers of such facilities to the local entities are made during fiscal year 1960, the termination of the revenue to the Commission from such operations will result in some increase in net cost to the Commission under this program.

The decrease in gross cost levels of $1,126,000, as reflected on the summary table, is attributed principally to the decreased cost of operation and maintenance of real estate at Oak Ridge, Tenn., and Richland, Wash., and is offset partially by increased costs at Los Alamos, N. Mex.

While the gross cost level decreases $1.1 million, the net cost to the Commission after application of revenues increases $0.2 million from fiscal year 1959 and increases $2.4 million from fiscal year 1958. This increase in net operating costs is attributable to the disposal of real estate at Oak Ridge and Richland with the resultant loss of income and higher costs at Los Alamos due principally to wage increases and increased school costs.

The revenues from community operations are included under the program "Revenues applied" as a reduction in the "Operating expenses" appropriation. A summary comparison of community operating costs and revenues is shown in a

table on the following page. Tables of operating costs and revenues by category for each community are included in the pages following:

Summary of community costs and revenues

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Operating costs:			
Oak Ridge, Tenn.	$7,327,375	$7,022,000	$6,570,000
Richland, Wash.	5,274,225	4,415,000	3,515,000
Los Alamos, N. Mex.	4,676,378	4,963,000	5,200,000
Sandia, N. Mex.	329,564	340,000	340,000
Grand Junction, Colo.	67,723	52,000	41,000
Total operating costs	17,675,265	16,792,000	15,666,000
Revenues (budgeted under "Revenues applied"):			
Oak Ridge, Tenn.	5,434,634	4,291,000	3,826,000
Richalnd, Wash.	4,778,551	2,678,000	1,815,000
Los Alamos, N. Mex.	4,776,331	4,880,000	4,915,000
Sandia, N. Mex.	460,200	460,000	460,000
Grand Junction, Colo.	64,152	51,000	40,000
Total revenues	15,513,868	12,360,000	11,056,000
Net operating costs:			
Oak Ridge, Tenn.	1,892,741	2,731,000	2,744,000
Richland, Wash.	495,674	1,737,000	1,700,000
Los Alamos, N. Mex.	−99,953	83,000	285,000
Sandia, N. Mex.	−130,636	−120,000	−120,000
Grand Junction, Colo.	3,571	1,000	1,000
Total net operating costs	2,161,397	4,432,000	4,610,000

OAK RIDGE

The fiscal year 1960 estimates for Oak Ridge are based on continued operation and maintenance by the AEC of all municipal facilities and utilities. Sale of real estate will continue in fiscal year 1959 resulting in a reduction in operating costs and revenues on real estate. Estimates are based on the assumption that 90 percent of all property will have been sold by the end of fiscal year 1959, and all property will have been sold by the end of fiscal year 1960 (see table II). The proceeds of the AEC real estate liquidation program were approximately $20 million through March 1959.

Residents of Oak Ridge voted on May 6, 1959, to incorporate with election of city officials to be held on June 2, 1959. This budget estimate is based on no assistance payments to a local entity in fiscal year 1960 on the assumption Oak Ridge will not be in a position to accept transfer of municipal installations, utilities, schools, and the hospital under the provisions of the Atomic Energy Community Act of 1955 until after fiscal year 1960. Since agreements have not been consummated with the local entities for the transfer of facilities (i.e. water, sewage, and electrical distribution systems, etc.), these budget estimates are based on the assumption of continued operation by the Commission of these facilities during fiscal year 1960. In the event that any transfers of such facilities to the local entities are made during fiscal year 1960, the termination of the revenue to the Commission from such operations will result in some increase in net cost to the Commission under this program.

The level of expenditures under direct AEC operation for municipal and school operations will support adequate standards of services. The number of persons employed in the various municipal activities does not exceed the average number employed in cities of comparable size elsewhere in the United States. Oak Ridge municipal per capita costs approximate national averages. At Oak Ridge the schools are supported entirely with AEC funds, there being no financial support from the State of Tennessee nor Anderson County.

Gross costs and revenues for hospital operations at Oak Ridge continue at approximately the same level as for the past few years. Hospital costs include consideration of only the minimum maintenance required to keep the present war-built facilities in repair until the new hospital can be completed. Rates charged for rooms and services compare with those prevailing in the general vicinity.

Additional details are presented in tables I and II on succeeding pages.

TABLE I.—*Oak Ridge*

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
1. Gross cost:			
(*a*) Municipal	$1,295,087	$1,341,000	$1,324,000
Schools	2,414,151	2,463,000	2,515,000
(*b*) Utilities	726,638	896,000	894,000
(*c*) Real estate operations	1,105,135	528,000	44,000
(*d*) Hospital	1,345,954	1,362,000	1,382,000
(*e*) Community disposal	285,313	275,000	268,000
(*f*) Equipment	155,097	157,000	143,000
Total gross costs, Oak Ridge	7,327,375	7,022,000	6,570,000
2. Revenue (budgeted under "Revenues applied"):			
(*a*) Municipal	873,248	933,000	946,000
(*b*) Utilities	1,460,090	1,487,000	1,530,000
(*c*) Real estate operations	1,782,039	536,000	15,000
(*d*) Hospital	1,319,257	1,335,000	1,335,000
Total revenue, Oak Ridge	5,434,634	4,291,000	3,826,000
3. Net:			
(*a*) Municipal	421,839	408,000	378,000
Schools	2,414,151	2,463,000	2,515,000
(*b*) Utilities	−733,452	−591,000	−636,000
(*c*) Real estate operations	−676,904	−8,000	29,000
(*d*) Hospital	26,697	27,000	47,000
(*e*) Community disposal	285,313	275,000	268,000
(*f*) Equipment	155,097	157,000	143,000
Net, Oak Ridge	1,892,741	2,731,000	2,744,000

TABLE II.—*Oak Ridge, Tenn.*

	Inventory, July 1, 1956	Number of units remaining unsold			
		Actual, June 30, 1957	Actual, June 30, 1958	Estimated, June 30, 1959	Estimated, June 30, 1960
Residential:					
Single and duplex housing	[1] 4,360	539	79	0	0
Apartments	[2] 258	258	254	54	0
Dormitories	7	7	4	0	0
Vacant and privately developed land	1,604	1,475	1,079	462	0
Subtotal, residential	6,229	2,279	1,416	516	0
Commercial and nonresidential	239	238	165	100	0
Grand total	6,468	2,517	1,581	616	0

[1] Includes 3,526 single-family houses and 834 duplex houses (1,668 family units).
[2] 2,080 family units

HANFORD

The fiscal year 1960 estimates for Richland are based on continued operation and maintenance by the AEC of all municipal facilities and utilties with the exception of the Kadlec Methodist Hospital, the Richland school system, and the community telephone system. As the sale of the community residential and commercial property continues, operating costs and revenues on real estate will decrease. Estimates are based on the assumption that 92 percent of all property will have been sold by the end of fiscal year 1959 with only a few commercial and nonresidential properties remaining unsold by the end of fiscal year 1960 (see table II). Proceeds of the AEC real estate liquidation program were approximately $26.4 million through March 1959.

Under the provisions of the Atomic Energy Community Act, Public Law 221, the Kadlec Methodist Hospital was transferred to the Methodist Board of Homes and Hospitals in September 1956 and the Richland school facilities were transferred to the Richland School District on December 15, 1958. Assistance payments which approximate the operating deficit anticipated for fiscal year 1960 are included for the hospital. Assistance payments to the school district for fiscal year 1960 were calculated by using the formula in Public Law 874 and were prepared with the assistance of the Department of Health, Education, and Welfare.

The city of Richland was incorporated in December 1958, when mayor and city councilmen were elected and the city charter approved. As the city government increases its capability to functtion and assumes the normal responsibilities of municipal government operation, the transfer of U.S. Government-owned plant and equipment as provided under Public Law 221, and the operation of service functions such as police, fire, water, and sewerage will be effected. Since agreements have not been consummated with the local entities for the transfer of facilities (i. e., water, sewage, and electrical distribution system, etc.), these budget estimates are based on the assumption of continued operation by the Commission of these facilities during fiscal year 1960. In the event that any transfers of such facilities to the local entities are made during fiscal year 1960, the termination of the revenue to the Commission from such operations will result in some increase in net cost to the Commission under this program.

The level of expenditures for municipal operation will support adequate standards of service. The number of people in the various municipal activities does not exceed the average number employed in other cities of comparable size in the United States.

Additional details are presented in tables I and II on succeeding pages.

TABLE I.—*Hanford*

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
1. Gross cost:			
(a) Municipal	$1,576,225	$1,687,000	$1,768,000
Schools (Public Law 221, assistance payments, fiscal year 1960)	988,823	1,094,000	835,000
(b) Utilities	523,234	589,000	621,000
(c) Real estate operations	1,673,752	689,000	75,000
(d) Hospital (Public Law 221, assistance payments)	210,659	113,000	47,000
(e) Community disposal	256,349	224,000	158,000
(f) Equipment	45,183	19,000	11,000
Total gross costs, Hanford	5,274,225	4,415,000	3,515,000
2. Revenue (budgeted under "Revenues applied"):			
(a) Municipal	432,632	565,000	545,000
(b) Utilities	1,148,033	1,220,000	1,250,000
(c) Real estate operations	3,197,886	893,000	20,000
Total revenue, Hanford	4,778,551	2,678,000	1,815,000
3. Net:			
(a) Municipal	1,143,593	1,122,000	1,223,000
Schools (Public Law 221, assistance payments, fiscal year 1960)	988,823	1,094,000	835,000
(b) Utilities	−624,799	−631,000	−629,000
(c) Real estate operations	−1,524,134	−204,000	55,000
(d) Hospital (Public Law 221, assistance payments)	210,659	113,000	47,000
(e) Community disposal	256,349	224,000	158,000
(f) Equipment	45,183	19,000	11,000
Net, Hanford	495,674	1,737,000	1,700,000

TABLE II.—*Richland, Wash.*

	Inventory July 1, 1956	Number of units remaining unsold			
		Actual June 30, 1957	Actual, June 30, 1958	Estimated, June 30, 1959	Estimated, June 30, 1960
Residential:					
Single and duplex housing	[1] 4,805	4,791	2,266	200	0
Apartments	[2] 17	17	17	9	0
Dormitories	25	25	2	2	0
Vacant and privately developed residential land	253	228	237	52	0
Subtotal residential	5,100	5,061	2,522	263	0
Commercial and nonresidential	325	325	282	162	66
Grand total	5,425	5,386	2,804	425	66

[1] Includes 3,787 single family houses, and 1,018 duplex houses (2,036 family units).
[2] 144 family units.

LOS ALAMOS

The community of Los Alamos, N. Mex., was built and is currently maintained to support the research and development efforts of the Los Alamos Scientific Laboratory. Average population during fiscal year 1958 was 13,200 and is expected to be 13,630 in fiscal year 1960. Municipal services will be maintained at the current year level even though salary adjustments provided for under recently negotiated contracts increase the costs of this subprogram. The enrollment of the Los Alamos school system will increase from 3,688 in fiscal year 1958 to 4,000 in fiscal year 1960. The additional staff required to accommodate the increase, higher teachers' salaries, and increased contribution to teachers' retirement fund will result in higher school costs in the budget year. The increased utility costs resulting from higher wages will be offset by additional revenues. Rising wage and material costs are responsible for higher real estate and hospital operating expenses.

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
1. Gross cost:			
(a) Municipal	$908,947	$930,000	$955,000
Schools	545,117	680,000	765,000
(b) Utilities	767,688	830,000	840,000
(c) Real estate operations	1,564,383	1,639,000	1,700,000
(d) Hospital	689,946	714,000	740,000
(e) Equipment	200,297	170,000	200,000
Total gross costs, Los Alamos	4,676,378	4,963,000	5,200,000
2. Revenue (budgeted under "Revenues applied"):			
(a) Municipal	16,351	17,000	17,000
(b) Utilities	1,323,742	1,325,000	1,340,000
(c) Real estate operations	2,952,207	3,030,000	3,040,000
(d) Hospital	484,031	508,000	518,000
Total revenue, Los Alamos	4,776,331	4,880,000	4,915,000
3. Net:			
(a) Municipal	+892,596	+913,000	+938,000
Schools	+545,117	+680,000	+765,000
(b) Utilities	−556,054	−495,000	−500,000
(c) Real estate operations	−1,387,824	−1,391,000	−1,340,000
(d) Hospital	+205,915	+206,000	+222,000
(e) Equipment	+200,297	+170,000	+200,000
Net, Los Alamos	−99,953	+83,000	+285,000

SANDIA

Sandia constitutes a small AEC community of 1,487 residents located within Sandia Base at Albuquerque, N. Mex. The Sandia Corp., operator of the laboratory, is responsible for the operation and maintenance of all AEC community facilities. Total program costs and revenues are expected to remain at the current year level.

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
1. Gross cost:			
(a) Municipal	$85,855	$80,000	$80,000
(b) Utilities	43,175	45,000	45,000
(c) Real estate operations	181,950	195,000	195,000
(d) Equipment	18,584	20,000	20,000
Total gross costs, Sandia	329,564	340,000	340,000
2. Revenue (budget under "Revenues applied"):			
(a) Utilities	67,055	67,000	67,000
(b) Real estate operations	393,145	393,000	393,000
Total revenue, Sandia	460,200	460,000	460,000
3. Net:			
(a) Municipal	+85,855	+80,000	+80,000
(b) Utilities	−23,880	−22,000	−22,000
(c) Real estate operations	−211,195	−198,000	−198,000
(d) Equipment	+18,584	+20,000	+20,000
Net, Sandia	−130,636	−120,000	−120,000

GRAND JUNCTION

The fiscal year 1960 estimate provides for operating rental housing at Monticello, Utah, and Grants, N. Mex.

The decrease in costs and revenues between fiscal year 1958 and fiscal year 1959, as reflected in the following schedule is a result of the disposition of housing at Slick Rock and Uravan, Colo., whereas the projected decrease between fiscal year 1959 and fiscal year 1960 is based on the anticipated disposal of Naturita, Colo.

	Actual fiscal year 1958	Estimate fiscal year 1959	Estimate fiscal year 1960
Real estate operations:			
Gross cost	$67,723	$52,000	$41,000
Revenues	64,152	51,000	40,000
Net	3,571	1,000	1,000

Mr. JENSEN. Mr. Chairman, may I say this off the record.

(Discussion off the record.)

USE OF ISOTOPES WITH RESPECT TO COAL AND GRAINS

Mr. FENTON. Before you leave the isotopes, I wonder if I could ask Dr. Aebersold this. You mentioned that you are doing some work on coal. Just what type of work?

Dr. AEBERSOLD. We have a contract—I do not know if you will like this—with the Bituminous Coal Association. I feel sure the findings will also apply to anthracite in many cases. This is to explore the possible uses of isotopes and radiation in the coal industry, all the way from mining, transportation, and so on, to the final problems of using

coal as chemicals, also to methods of upgrading coal to try to find a way of making coal a more high value fuel, such as by powdering it, hydrogenating it, et cetera.

There is a possibility that radiation can be useful in large quantities for that purpose. In our first year here we are doing largely exploratory contracts, but we do plan to support work and work with agencies such as you mentioned that are being set up to do research for the whole coal industry.

Mr. FENTON. That is a very fine thing, I think, as far as coal is concerned. I am just curious to see, on the one hand, where we try to eliminate coal as a power producer and, on the other hand, try to help them improve their coal, the whole thought, of course, behind the matter being to sell the product. Perhaps it will have some effect on that part of it. Thank you, Mr. Chairman.

Mr. JENSEN. I am hoping the day will come very soon when the Atomic Energy Commission or someone else will discover how to extract alcohol from grains cheaply so we can then use this grain alcohol in our motor fuel and by so doing soon consume this great surplus of grains which the Government has in storage.

Mr. CANNON. Which was once consumed by the Missouri mules.

Mr. JENSEN. Before the advent of the Iron Horse our flesh and bone horses and mules used the production of 43 million acres of our land. Knowing that, no one need wonder why we have a great surplus of grain, especially since we have all these new hybrids and new fertilizers which even the Atomic Energy Commission is assisting in making more effective. So I hope that our scientists will put themselves to work in developing a process by which alcohol can be extracted from grain.

Mr. McCone, can I have the assurance that you will look into that field?

Mr. MCCONE. Yes, sir. There is no money provided in the budget for it. We will have to do it after hours.

Mr. JENSEN. Would you do it if we would provide some money? There is some sense to it. If you could do the almost impossible—we thought it was impossible a few years ago with isotopes—then certainly the extraction of alcohol from grain is possible by some method which you folks have the ability to find. I would not hesitate, as much of a nickel pincher as I am with the American people's money, even without a budget request to ask this committee to include a few thousand dollars to start looking into that field.

I am very serious about this. I just believe that with the great brains that are contained in the heads of the Atomic Energy Commission and your great and wonderful and efficient and intelligent staff, you can come up with the answer and really do a great job for America and for the world.

PROGRAM DIRECTION AND ADMINISTRATION

Mr. CANNON. Under "Program direction and administration" you are asking $52 million. We will insert pages 226 through 243.

(The pages follow:)

PROGRAM DIRECTION AND ADMINISTRATION—OPERATING COSTS

Program statement

Estimate fiscal year 1960	$52,000,000
Estimate fiscal year 1959	49,803,000
Increase	2,197,000

General direction of Commission programs is executed by Commission employees budgeted under "Program direction and administration." These employees are responsible for (1) arranging for the work to be accomplished, and negotiating and administering production, research and development, construction, and related contracts; (2) maintaining necessary liaison with contractors to assure protection of the Government's interest in contract performance; (3) developing standards and control measures for internal security and protection of Government funds and property; (4) encouraging private civilian applications of atomic energy, granting licenses for peaceful uses of atomic energy; and conducting compliance inspections of licensees; (5) conducting a program of cooperation with other nations, regional groups such as the European Atomic Energy Community, and the International Atomic Energy Agency; and (6) providing normal administrative and management services required within the agency.

Program direction and administration activities are conducted through the Headquarters and 12 operations offices and their subordinate area and branch offices.

The costs of program direction and administration include the costs of personal services, travel, supporting costs for office operation and maintenance, certain activities conducted directly by the Commission, contributions to civil service retirement fund and cost of administrative equipment. The estimates are based on progressive recruitment in fiscal year 1960 to reach by June 30, 1960 a strength of 4,870 full-time permanent employees, which represents an increase of 121 over the estimated strength of 4,749 employees on June 30, 1959.

Summary of Estimates by Category

Category	Actual fiscal year 1958	Estimate fiscal year 1959	Estimate fiscal year 1960
1. Personal services	$34,351,329	$37,763,000	$38,845,000
2. Travel	2,240,938	2,178,000	2,400,000
3. Other objects	8,749,458	9,526,000	10,083,000
4. Equipment not included in construction projects	603,975	336,000	672,000
Total, program direction and administration	45,945,700	49,803,000	52,000,000

JUSTIFICATION OF CATEGORIES

1. Personal services, $38,845,000

This budget provides for an average employment in fiscal year 1960 of 4,810 permanent full-time employees, plus a small number of professional and scientific consultants whose services are utilized intermittently for limited periods, and a small number of employees in temporary positions to meet special situations. A breakdown of total personal services costs under this program follows:

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
(a) Net cost of permanent full-time employees, including terminal leave costs	$33,347,329	$36,703,000	$37,581,000
(b) Costs of other employees	373,000	416,000	388,000
(c) Regular pay in excess of 52-week base	127,000	141,000	289,000
(d) Payment above basic rates	483,000	468,000	561,000
(e) Reimbursement to other agencies	21,000	35,000	26,000
Total, personal services	34,351,329	37,763,000	38,845,000

a. Net cost of permanent full-time employees, including terminal leave costs:

Fiscal year 1958	$33,347,329
Fiscal year 1959	36,703,000
Fiscal year 1960	37,581,000

The estimates provide for employment at the beginning and end of the fiscal year as follows:

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Starting employment	4,687	4,829	4,749
Ending employment	4,829	4,749	4,870
Computation of the dollar estimates:			
(1) Average employment	4,697	4,782	4,810
(2) Plus man-year equivalent for terminal leave costs	25	23	25
(3) Total permanent man-years	4,722	4,805	4,835
(4) Average man-year cost	$7,062	$7,639	$7,773
(5) Net cost of permanent full-time employees, including terminal leave costs (line 3 multiplied by line 4)	$33,347,329	$36,703,000	$37,581,000

The man-year equivalent for terminal leave payments covering estimated separations from Government employment is based on current experience.

The average permanent full-time man-year cost reflects an increase of $134 in fiscal year 1960. This increase is accounted for chiefly by automatic ingrade advancements, organizational changes, and reclassifications resulting from job reevaluations.

Justification for increase of permanent full-time employees.—The estimates for personal services under this program would provide for an increase of 121 permanent full-time employees in fiscal year 1960 over the estimated strength of 4,749 on June 30, 1959, to reach a total of 4,870 by June 30, 1960. The requirement for additional staff is justified in detail in subsequent pages of this budget for the following purposes: (1) implementation of safeguards and control provisions of bilateral agreements for cooperation, (2) international cooperation activities other than international safeguards program, (3) completion of staffing of new operations offices, (4) inspection of domestic licensees, and (5) administration and supervision of technical programs.

While it has been and is the policy of the Commission to absorb personnelwise, new programs and expansions of existing programs to the maximum extent possible, the increasing accumulation of workload in fiscal year 1960 is beyond the capacity of the maximum staff that can be provided in fiscal year 1959 within funds available for this program. Over a period of the 4 years ending June 30, 1960, the personnel strengths of this program reflect only minor changes in the face of continuing significant increases in overall operating costs, especially in the major research and development programs (reactor development; physical research; and biology and medicine) as is shown by the following table:

	Total gross operating costs (in millions)	Percentage change from fiscal year 1957	Gross operating costs for major research and development programs (in millions)	Persentage change from fiscal year 1957	Personnel end-year strength	Percentage change from fiscal year 1957
Fiscal year 1957 actual	$1,738.7		$357.4		4,687	
Fiscal year 1958 actual	2,129.6	+22.5	434.9	+21.7	4,829	+3.0
Fiscal year 1959 estimated	2,331.4	+34.1	504.2	+41.1	4,749	+1.3
Fiscal year 1960 estimated	2,520.9	+45.0	609.7	+70.6	4,870	+3.9

While the increased operating costs of the Commission have not resulted in the need for an increase in program direction and administration personnel in direct proportion to the increase in operating costs, the impact on the workload has been very substantial. Contracts continue to increase in number, diversity, and complexity especially in the field of research and development. For example, the number of operating contractors whose employment plus first-tier subcontractor employment totaled 50 or more increased by 16 percent from December 31, 1957, to December 31, 1958; and offsite research contracts with educational, medical and other nonprofit institutions increased by 8 percent from June 30, 1957, to June 30, 1958. The added responsibilities placed on the Commission by the Atomic Energy Act of 1954, as amended, require more and more manpower as programs get underway, pass from one phase to another, or expand as interest in atomic energy grows in this and friendly foreign countries. Significant numbers of personnel are now required for programs initiated only

a few years ago or very recently in some cases, such as: industrial participation activities: licensing and regulatory activities under which it is estimated that 10,000 licenses will have been issued by June 30, 1960; inspection of licensees for compliance with the Atomic Energy Act, rules and regulations of the AEC, and conditions imposed by the license; the cooperative arrangements program for development of civilian atomic power; peaceful applications of atomic energy under Project Plowshare; and the many facets of the atoms for peace program involving formal bilateral agreements for cooperation with 41 nations as of March 31, 1959, and cooperation with and assistance to the International Atomic Energy Agency (IAEA), the European Atomic Energy Community (Euratom), and other regional groups.

In spite of increasing workload, it has been necessary to reduce employment in fiscal year 1959 from the level previously planned for the year and from the actual strength of June 30, 1958, in order to operate within funds available for this program. The reduction is being accomplished by not filling vacancies. This condition results from the fact that the average salary this year is greater than was estimated in the fiscal year 1959 budget, due principally to a wider application throughout the Commission and greater costs for salary increases for scientific and engineering personnel under Civil Service Commission Circular 793 than were anticipated when the budget was prepared. While it is not proposed to fill in fiscal year 1960 all of the vacancies which could not be filled in fiscal year 1959, the increased workload will require that 121 additional employees be provided. The most urgent areas in which increased staff is required were identified above. The requirements are detailed below:

1. International safeguards program:

Headquarters	22
Field offices	0
Total	22

The primary objective of this program is to insure under the safeguards and control provisions of bilateral agreements for cooperation that materials, equipment and facilities made available for peaceful purposes, and nuclear materials produced as a result of the foregoing, are used only for peaceful purposes and are not diverted to military uses. The administration of the safeguards program is assigned to the Headquarters Division of International Affairs. It includes overall coordination of the program; the accountability for source and special nuclear materials distributed abroad; development of related procedures, instruments and methods; coordination of safeguards and controls policy with other nations and international groups; and inspection activities including the training of inspection teams.

It is estimated that a staff of 42 employees will be required by June 30, 1960, to conduct a minimum acceptable program consonant with Commission responsibilities. It is planned that the staff will reach a total of 20 employees during fiscal year 1959, the bulk of whom will be engaged in developing policy, training programs, procedures manuals for foreign governments on materials control, and AEC administrative records and control systems. Due to a lack of trained inspection personnel, the majority of inspections in fiscal year 1959 will be accomplished through the temporary detail of personnel of various other organizational units. Staff requirements will increase as additional facilities enter into the design, construction, and operational phases. It is expected that inspections of 53 facilities will be required in fiscal year 1960: 43 reactors with power levels up to 10 TMW, 7 reactors with power levels over 10 TMW, and 3 fabrication facilities. Of the requested staff increase of 22 in fiscal year 1960, 18 would be professional and scientific, while 4 would be clerical and administrative. By the end of fiscal year 1960 it is planned to have 3 inspection teams of 3 employees each; 8 inspection personnel in training; 2 employees for design review and related work; 2 employees engaged in materials accountability work; 10 employees for overall direction, coordination, and administration; and 11 clerical personnel.

2. International cooperation activities other than international safeguards program:

Headquarters	18
Field offices	0
Total	18

This increase in personnel is required to keep pace with the continuing expansion of work in the field of international cooperation, related to the European

Atomic Energy Community, the International Atomic Energy Agency, other regional groups, and individual nations.

United States-Euratom joint program.—Significant responsibilities have been placed on the Commission by the enactment of the Euratom Cooperation Act of 1958 (Public Law 85–846). Overall responsibility for assuring that all phases of the joint United States-Euratom program are properly coordinated and administered has been assigned to the Headquarters Division of International Affairs, including the support and administrative direction of the AEC Brussels Office, liaison with other government agencies and formulation and negotiation of new programs of cooperation. The Headquarters Division of Reactor Development will be responsible for the technical coordination and administration of the research and development program, reviewing and recommending on proposals, budgeting for requirements, and negotiation, execution and administration of contracts. The workload created by this act is already in evidence and is expected to increase rapidly and substantially. For example, as of April 22, 1959, the Commission had received 44 research and development proposals for review and handling.

Emergency measures have been used to make a minimum number of employees available for the initial phases of the program in fiscal year 1959, including the temporary detail of some employees from their regular duties. In order to handle the expected workload in fiscal year 1960, it is estimated that 10 additional employees will be necessary to augment the staffs of the Division of International Affairs, the Brussels Office, and the Division of Reactor Development.

Joint AEC–DOD exchange group.—Additional workload has been imposed by sections 144 b and c, of the Atomic Energy Act of 1954, as amended, which authorize under certain conditions the exchange of restricted data with other nations and regional defense organizations to which the United States is a party. The law imposes joint responsibilities on the part of the Atomic Energy Commission and the Department of Defense. It will be necessary for the Commission to assign a staff of five employees to a joint AEC–DOD group organized to carry out the joint responsibilities of the two agencies. The joint AEC–DOD group will be staffed by the two agencies on a 50–50 basis.

Organization of American States.—The Organization of American States (OAS) is establishing the Inter-American Nuclear Energy Commission (IANEC). It is expected that IANEC will be organized in September 1959 and will have as its purpose the centralization of a cooperative effort among the Latin-American countries in the development of individual or joint atomic energy programs. It is estimated that a minimum of two employees will be required in the Division of International Affairs to handle the initial phases of this new program in fiscal year 1960.

International Atomic Energy Agency.—A small group has been established in the headquarters to coordinate relationships with the International Atomic Energy Agency. It is planned that this group will consist of five employees by the end of fiscal year 1959. It is proposed to add a technical coordinator in fiscal year 1960 to provide technical guidance and support, coordinate working arrangements within the Commission and maintain liaison on technical matters with other interested government agencies and industry.

Staffing of new operations offices:

Headquarters	0
Field offices	28
Total	28

Lockland Aircraft reactors operations office.—In July 1958, the Lockland area office was redesignated the Lockland Aircraft reactors operations office with a subordinate area office located in Middletown, Conn., and a test office in Idaho, and was assigned the full responsibilities and functions of an operations office. At the time of the redesignation, a staffing study indicated that the added responsibilities and functions would require a minimum staff of 90 or an increase of 34 over the June 30, 1958, strength. Due to the necessity to hold down overall employment in order to operate within total funds available for this program in fiscal year 1959, a staff of only 70 people could be authorized. Experience this year has clearly demonstrated that the Lockland operations office cannot fulfill its responsibilities as an operations office with this staffing complement. Only priority assignments are being performed on a current basis. In the areas of procurement, property management, health and safety, security, SS materials accountability, and technical review the shortage of staff is particularly apparent.

Complicating this existing problem are additional responsibilities related to: (1) the completion of such Idaho test facilities as the flight engine test plant, the shield test pool facility, the low power test facility and the hot cell area; (2) the start of construction of additional test plants at the National Reacor Testing Site; and (3) the intensification of experimental testing. A minimum of 20 additional employees will be necessary in fiscal year 1960 to enable this office to execute properly its current responsibilities.

Pittsburgh naval reactors operations office.—In March 1958, the Pittsburgh area office was redesignated the Pittsburgh naval reactors operations office with the Idaho and Shippingport branch office as subordinate offices. This change was one of several organizational changes which consoliadted administration and technical supervision in the naval reactors field. Staffing studies indicated a requirement for a minimum staffing complement of 100 employees, which was planned to be reached in fiscal year 1959; however, within the total funds available under this program it has been possible to authorize only 92 employees for the office in fiscal year 1959. New projects—natural circulation reactor and high temperature test facility—together with the beginning of the full operation of the A1W prototype with two reactor plants, will require additional staffing of technical and supervisory positions. In addition, there will be an overall work increase in the area of technical supervision of the development of core fabrication processes and advanced type fuel elements. This will apply in particular to the S1W reactor facility (S1W core 5), PWR core 2 (Shippingport), and seven critical experiments. In order to handle the workload and enable the office to fulfill its responsibilities in fiscal year 1960, eight additional employees will be required.

4. Inspection of domestic licensees:

Headquarters	0
Field offices	22
Total	22

The Commission is responsible for inspecting licensees for compliance with the Atomic Energy Act of 1954, rules and regulations of the Commission, and conditions imposed by the license.

There are two major categories of licensed activities requiring inspection: (1) use of licensed materials (byproduct, source, and special nuclear materials) and (2) construction and operation of production and utilization facilities. Responsibility for inspection of the first category has been decentralized to operations offices, and each office has been assigned a geographic area for coverage. Inspection of the second category is being accomplished by headquarters personnel.

The primary purpose of the licensee inspection program is to assure that the operations and facilities of licensees do not constitute a danger to the health and safety of employees or the public or a danger to the common defense and security. Criteria provide for scheduling of initial and subsequent inspections utilizing a priority system, based on the relative potential hazard involved in a licensed operation. The system provides for initial inspection on a schedule determined by the kind of operation and the relative hazard involved; followup inspection after administrative regulatory action has been completed where substantial noncompliance was observed on a previous inspection; reinspections on a nominal frequency of 1 to 5 years, depending on the degree of potential hazard; and special inspections and investigations of unusual situations. Experience indicates that special inspections and investigations of unusual situations now require about 10 percent of the available manpower. As the number of licenses increases the number of special inspections and investigations can be expected to increase. The program in fiscal year 1960 will continue in conformity with the policies and procedures outlined above.

The following table reflects the trend of materials licenses:

Active licenses, June 30, 1957	4,000
Active licenses, June 30, 1958	6,300
Active licenses, Mar. 31, 1959	9,000
Estimated active licenses, June 30, 1960	10,000

In order to be able to handle the increasing workload responsibility, additional trained and experienced personnel are required. Based on experience to date and the estimated number of materials licensees to be inspected, there will be a minimum requirement in fiscal year 1960 of 58 professionals, supported by 24 administrative and clerical personnel in field offices. This would represent

an increase of 16 professionals and 6 administrative and clerical personnel over the estimated employment on June 30, 1959.

5. Administration and supervision of technical programs:	
Headquarters	2
Field offices	29
Total	31

Expansion and growing complexities of technical programs will require small increases in several offices for administration and supervision of contracts and other related duties. The principal areas in which additional workload has recently developed and will continue to expand in fiscal year 1960 beyond the capacity of the present staff are:

(*a*) The new production reactor authorized in the fiscal year 1959 authorization act at an estimated cost of $145 million, will significantly increase the workload of the Hanford operations office over a period of several years. It is estimated that 10 additional employees will be required at Hanford in fiscal year 1960 to handle the impact of this project, principally in contracting, construction engineering administration, procurement and property management, and fiscal activities. It has been necessary previously to increase the staff of this office during periods of major construction, and then reduce the size of the staff as the construction was phased out. From fiscal year 1952 to fiscal year 1956 a major expansion was underway. The following program direction and administration strengths for the Hanford office reflect the reductions in employees as the program was completed.

Strength, June 30, 1953	421
Strength, June 30, 1954	356
Strength, June 30, 1955	294
Strength, June 30, 1956	263

(*b*) The scope of Project Plowshare in fiscal year 1960 as outlined in the narrative justification for this project in the budget will significantly increase the workload of the headquarters and the San Francisco operations office, due to negotiation of additional contracts and coordination and administration of the overall program. The budget provides for an increase in staff for these purposes of two employees in the headquarters and three employees in the San Francisco operations office.

(*c*) The research and development programs of the Commission continue to reflect increases in dollar volume, number of contracts, diversification, and complexity, particularly in the field of reactor development. For the reactor development program, this budget provides for increased costs in fiscal year 1960 of about $65 million, which represents an increase of about 19 percent over the fiscal year 1959 level. The resulting additional workload cannot be absorbed in field offices by staff available in fiscal year 1959. It is estimated that an increase of 16 employees will be required in field offices in fiscal year 1960 to provide for staffing commensurate with the workload, as follows: 2 in San Francisco, 4 in Chicago, 6 in Idaho, and 4 in New York.

The following table reflects by office the actual strength of permanent full-time employees as of June 30, 1958, and the currently planned distribution at June 30, 1959, and June 30, 1960:

Office	Actual strength, June 30, 1958	Estimated strength, June 30, 1959	Estimated strength, June 30, 1960
Grand Junction	127	119	119
Hanford	247	254	264
Oak Ridge	699	665	665
Savannah River	228	220	220
Albuquerque	803	780	780
San Francisco	159	163	170
Chicago	282	276	287
Idaho	152	156	163
Lockland	[1] 56	70	90
New York	203	210	226
Pittsburgh	84	92	100
Schenectady	99	90	90
Washington headquarters and extensions	1,690	1,654	1,696
Total	4,829	4,749	4,870

[1] Lockland was an area office under the Chicago operations office through June 30, 1958. It was redesignated the Lockland aircraft reactors operations office effective July 1, 1958.

(*b*) Costs of other employees:

Fiscal year 1958	$373,000
Fiscal year 1959	416,000
Fiscal year 1960	388,000

These costs cover salaries of temporary, part-time, and intermittent employees. The bulk of these costs in fiscal year 1960 is for salaries of personnel who are paid only when employed, such as members of the General Advisory Committee, the Patent Compensation Board, the Advisory Committee for Reactor Safeguards, other boards, committees, panels, and consultants and experts.

(*c*) Regular pay in excess of 52-week base:

Fiscal year 1958	$127,000
Fiscal year 1959	141,000
Fiscal year 1960	289,000

These costs cover salaries of permanent employees for days of pay in excess of 260 days of pay in 1 fiscal year. Two extra days of pay are involved in fiscal year 1960.

(*d*) Payment above basic rates:

Fiscal year 1958	$483,000
Fiscal year 1959	468,000
Fiscal year 1960	561,000

These costs cover payments for scheduled and emergency overtime, nightwork differential, living and quarters' allowances and other authorized special allowances for AEC employees stationed overseas. The increased costs in fiscal year 1960 are related primarily to living and quarters and special overseas allowances associated with higher levels of staffing in foreign offices.

(*e*) Reimbursement to other agencies:

Fiscal year 1958	$21,000
Fiscal year 1959	35,000
Fiscal year 1960	26,000

These costs in fiscal year 1960 cover reimbursement to the Department of State for furnishing secretarial service at the Johannesburg, South Africa, office and reimbursement to other agencies for services such as preparatory work in connection with overseas exhibits.

2. Travel, $2,400,000

This estimate covers the cost of domestic and foreign travel chargeable to program direction and administration. The travel costs under this program include the travel of three principal classes of personnel: (1) AEC permanent full-time employees; (2) AEC intermittent employees such as members of advisory groups and individual consultants; and (3) approximately 250 military personnel on duty with the AEC, whose salaries are paid by the Department of Defense, but whose duties require considerable travel on AEC business.

The amount requested is based on estimated requirements to discharge effectively overall Commission responsibilities, and includes travel essential for—

(1) A satisfactory degree of technical and administrative supervision over field offices and projects and liaison with contractors;

(2) Carrying out added responsibilities resulting from passage of the Atomic Energy Act of 1954, as amended, such as regulatory activities under the civilian application program, inspection of licensed facilities, and cooperation with State and local governments and private industry in many forms;

(3) Administering effectively the program of cooperation with other nations;

(4) Liaison with the International Atomic Energy Agency and regional groups such as Euratom;

(5) Attendance of technical and scientific personnel at important domestic and foreign conferences and symposia;

(6) Coordination of and participation in overseas nuclear energy exhibits;

(7) Implementation of safeguards and control provisions of bilateral agreements for cooperation; and

(8) Necessary travel of advisory committees, boards, and consultants.

A generally increased level of travel is indicated in practically all areas mentioned above, as the overall program of the Commission continues to grow in complexity and variety, with a constantly increasing workload in program direction and administration. Travel in connection with implementation of safeguards and control provisions of bilateral agreements for cooperation becomes significant in fiscal year 1960.

3. Other objects, $10,083,000

This estimate covers all costs of operations at the headquarters and in the field chargeable to Program Direction and Administration except personal services, travel and equipment. The chief items included are transportation of things, communications, rents, utilities, printing and reproduction, various contractual services rendered by civilian contractors and other Government agencies, maintenance and operation of buildings and grounds, supplies and materials, and contributions to the civil service retirement fund.

The breakdown of requirements between field offices and the headquarters is—

Field offices	$ 5, 114, 000
Headquarters and extensions	4, 969, 000
Total	10, 083, 000

Field offices.—The fiscal year 1960 requirement for field offices, except for contributions to the civil service retirement fund, is based on past experience of requirements for effective, yet economical operations, and is related directly to the estimated average employment. Additional costs will be incurred in fiscal year 1960 over past experience for specific items, such as increases in telephone rates, rental of commercial space for the Lockland Operations Office due to insufficiency of space formerly provided by the General Electric Co. for the Lockland area office, rental of additional space to meet expanded requirements of the San Francisco Operations Office, and increased costs billed by contractors for services, resulting chiefly from wage rate increases.

A breakdown of costs in field offices by activity for 3 years follows:

Activity	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Transportation of things: Includes transportation of Government property and employees' household goods	$72, 973	$79, 000	$80, 000
Communications services: Includes costs of telephone service including equipment and circuit rental, and teletype service	919, 907	879, 000	930, 000
Rents and utilities: Includes costs of rental of office and other administrative space and utilities	588, 412	596, 000	670, 000
Printing and reproduction: Includes charges for printing, binding, photostating and reproduction services	141, 284	123, 000	140, 000
Other contractual services: Covers costs of maintenance and operation of administrative buildings and equipment, contributions to Federal employees' life insurance fund, guard services, and various services performed by other agencies and private contractors	1, 347, 798	1, 274, 000	1, 354, 000
Supplies and materials: Includes costs of general office supplies, technical and professional books and gasoline, oil and parts for Commission-owned vehicles	379, 370	360, 000	380, 000
Grants, subsidies and contributions: Covers costs of civil service retirement contributions	1, 310, 475	1, 502, 000	1, 542, 000
Refunds, awards, and indemnities: Covers costs of employee awards given under the incentive awards program, and payments under Tort Claims Act	13, 468	15, 000	15, 000
Taxes and assessments: Includes costs of contributions under Federal Insurance Compensation Act	1, 700	3, 000	3, 000
Total, field offices	4, 775, 387	4, 831, 000	5, 114, 000

Headquarters and extensions.—The fiscal year 1960 estimate reflects for the first time the costs of a full year's occupancy of the expanded Germantown headquarters. A small office will also be maintained on a permanent basis in the District of Columbia. The estimate also reflects increases resulting from a higher level of employment, expansions in foreign offices, and provision for essential requirements under various specific items. Requirements for fiscal year 1960 have been developed by detailed analysis of needs under the various activities to provide the level of services and materials required for economical and efficient operations.

A breakdown of costs in the headquarters by activity for the 3 years follows:

Activity	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Transportation of things (includes costs for shipments of supplies and materials, transportation of Government property, and shipment of household goods of employees in connection with domestic and foreign transfers)	$145,902	$94,000	$96,000
Communications services (covers costs of telephone service including equipment and circuit rental and installation costs, long-distance toll calls and tieline services, teletype service; and payments to the Post Office Department in lieu of postage)	956,140	1,082,000	1,130,000
Rents and utilities (includes costs of electric power, water and sewage charges at Germantown, and rental of specialized equipment)	45,753	136,000	153,000
Printing and reproduction (includes costs of printing forms, letterheads, routine reports, etc.; special printing and duplicating services performed by other agencies; and contractual duplicating services for press releases and informational materials)	321,268	276,000	292,000
Other contractual services (includes operation and maintenance of buildings and grounds, guard services, and motor transportation services provided by General Services Administration; administrative support furnished by Department of State for foreign offices; other miscellaneous services performed by other agencies; services contracted for, such as repairs and maintenance of equipment, transportation, reporting services for conferences and hearings, and official entertainment both at headquarters and field offices; and employees group life insurance)	1,357,791	1,871,000	2,064,000
Supplies and materials (includes costs of office and other supplies; technical and professional books; gasoline, oil, and parts for Commission-owned vehicles; and Commissionwide subscriptions for newspapers and periodicals)	287,773	298,000	310,000
Grants, subsidies, and contributions (includes costs of contributions to the civil service retirement fund and in fiscal year 1958 and fiscal year 1959 only, commuting transportation for employees)	843,161	925,000	906,000
Refunds, awards and indemnities (includes costs of employee incentive awards program)	13,602	10,000	15,000
Taxes and assessments (includes cost of contributions under Federal Insurance Contributions Act)	2,681	3,000	3,000
Total, headquarters and extensions	3,974,071	4,695,000	4,969,000
Equipment not included in construction projects			672,000

This category covers replacement and additional administrative equipment such as office machines and furniture, motor vehicles and operating equipment required at the headquarters and field offices. The requirement in fiscal year 1960 breaks down into four major parts which are justified below:

(*a*)	Additional office furniture and machines for staff increases	$35,000
(*b*)	Additional miscellaneous equipment not related to staff increases	42,000
(*c*)	Terminal radio and cryptographic equipment	250,000
(*d*)	Replacement equipment	345,000
	Total	672,000

(a) *Additional office furniture and machines for staff increases.*—The budget provides for an increase in staff of 121 employees in fiscal year 1960 over the estimated strength at June 30, 1959. It is estimated that additional office furniture and machines will be required for 70 of these employees.

(b) *Additional miscellaneous equipment not related to staff increases.*—This requirement covers miscellaneous equipment such as special files, library equipment, reproduction equipment, miscellaneous office equipment in all offices and various types of equipment required in the warehouse and for grounds maintenance at the headquarters.

(c) *Terminal radio and cryptographic equipment.*—Emergency exercises have demonstrated inadequacies in the AEC's emergency communications capability. As an immediate measure to improve the capability, it is planned to procure additional radio and cryptographic equipment. The estimate for fiscal year 1960 provides for procurement of (1) long and medium range radio units to provide minimum transmitting facilities should land lines linking our principal emergency relocation centers become inoperative, and (2) portable cryptographic units to provide cryptoteletype capability under many conditions prevalent during emergencies when existing facilities will not function or are inadequate.

(d) *Replacement equipment.*—This requirement is for the replacement of equipment meeting prescribed replacement criteria and other equipment which is unserviceable or on which further repairs are uneconomical.

The breakdown of the fiscal year 1960 estimate between the headquarters and field offices is:

Headquarters	$422,000
Field offices	250,000
Total	672,000

Security Investigations

Mr. Cannon. Under "Security investigations" you are requesting $7,390,000. We shall insert pages 244 through 247.

(The pages follow:)

Security Investigations Program—Operating Costs

Program statement

Estimate, fiscal year 1960	$7,390,000
Estimate fiscal year 1959	7,506,000
Decrease	116,000

This program includes cost of security investigations of individuals for whom clearance is required by the Atomic Energy Act of 1954, as amended. Cost of investigations of individuals for whom security clearance is required under the access permit program is excluded. This is budgeted under "Other costs."

The Atomic Energy Act of 1954, as amended, provides that no individual shall be permitted access to restricted data until the U.S. Civil Service Commission, or, under certain conditions, the Federal Bureau of Investigation shall have made an investigation and report to AEC on the character, associations and loyalty of the person concerned and the AEC shall have determined that permitting such individual access to restricted data will not endanger the common defense and security. Published policies and procedures provide guidance in determining need for AEC security clearance.

Pursuant to provisions of section 145(e) of the Atomic Energy Act, as amended, distribution of total investigative caseload between the Civil Service Commission and the Federal Bureau of Investigation is based on Commission-approved criteria. Requests for investigation for individuals who are to occupy positions of a high degree of importance or sensitivity are referred to the Federal Bureau of Investigation; all others to the Civil Service Commission.

The Commission-approved program for selective reinvestigation of previously cleared personnel continues in order to assure that the program is protected from individuals whose clearance eligibility may have changed since time of last clearance action in their cases.

Clearance needs of AEC contractors account for about 79 percent of the 22,500 Q-type investigations budgeted for fiscal year 1960. Clearances of AEC personnel represent 7 percent of the total requirement, reinvestigations of persons previously cleared 4 percent and clearances of others, including suppliers and employees of other Government agencies, amount to 10 percent.

The following table shows the estimated number of new cases to be referred to the investigating agencies, the number of cases in process at the end of the year, and the estimated number of cases completed for both full background investigations (Q clearance) and National Agency checks (L clearance). Costs are expressed in the number of completed units of investigation multiplied by the unit cost per investigation. Unit costs are those furnished by the investigating agencies.

Summary of estimates

Item	Actual, fiscal year 1958		Estimate, fiscal year 1959		Estimate, fiscal year 1960	
	Q	L	Q	L	Q	L
1. Number of new cases referred to investigating agency:						
Federal Bureau of Investigation	7,300		5,500		4,000	
Civil Service Commission	17,305	6,682	17,600	6,500	18,500	6,500
Total	24,605	6,682	23,100	6,500	22,500	6,500
2. Number of cases in process at end of year in investigating agency:						
Federal Bureau of Investigation	586		500		400	
Civil Service Commission	2,275	251	2,385	250	2,535	250
Total	2,861	251	2,885	250	2,935	250
3. Cases completed during year:						
Federal Bureau of Investigation	7,373		5,586		4,100	
Civil Service Commission	19,183	6,836	17,490	6,501	18,350	6,500
Total	26,556	6,836	23,076	6,501	22,450	6,500
4. Cost of completed investigations:						
Q clearances:						
Number completed by Federal Bureau of Investigation	7,373		5,586		4,100	
Cost per investigation	[1] $258.02		$285.00		$285.00	
Total cost, FBI	$1,900,985		$1,592,010		$1,168,500	
Number completed by Civil Service Commission	19,183		17,490		18,350	
Cost per investigation	[1] $299.56		$335.00		$335.00	
Total cost, CSC	$5,746,440		$5,859,150		$6,147,250	
Total Q clearances	$7,647,425		$7,451,160		$7,315,750	
L clearances:						
Number completed by Civil Service Commission		6,836		6,501		6,500
Cost per investigation		[1] $5.82		$6.57		$6.57
Total L clearances (CSC)		$39,797		$42,712		$42,705
Total cost of completed cases	$7,687,222		$7,493,872		$7,358,455	
5. Adjustment for partially completed cases at end of year	−$91,491		+$12,128		+$31,545	
6. Total security investigations program	$7,595,731		$7,506,000		$7,390,000	

[1] Average cost.

The estimated number of cases to be referred for full field investigation (item 1 of the preceding table) is summarized below:

Full field investigations (Q clearance)

Category	Actual fiscal year 1958	Estimated fiscal year 1959	Estimated fiscal year 1960
AEC	1,612	1,410	1,650
Contractor:			
Construction	2,373	1,835	2,169
Operating	16,088	16,388	15,631
All other	2,779	2,367	2,250
Reinvestigations	1,753	1,100	800
Total	24,605	23,100	22,500

Other Costs

Mr. Cannon. Under "Other costs," you are requesting $5,673,000. We shall insert pages 248 through 251.

(The pages follow:)

Other Costs

Program statement

Estimate, fiscal year 1960	$5,673,000
Estimate, fiscal year 1959	6,585,000
Decrease	912,000

Under the program "Other costs" the Commission budgets for certain costs incurred in the manufacture of materials, which it sells to eligible purchasers, and in rendering laboratory, research, and other services to industrial and research organizations. Reimbursements received by the Commission for the cost of products and services are applied to reduce the Commission's fund requirements. They constitute an offset against "Other costs" and are shown under the program "Revenues applied." The decrease in estimated costs is related primarily to a decreased level of sales of heavy water. The decrease is partially offset by an increased level of sales of isotopes and increased use of irradiation services.

Summary of estimates by category

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
1. Other costs:			
(a) Cost of special reactor materials sold	$2,808,229	$2,134,000	$900,000
(b) Cost of isotopes	2,375,058	2,607,000	2,792,000
(c) Cost of other products	0	14,000	14,000
(d) Cost of services	651,852	1,217,000	1,372,000
(1) Use of AEC facilities and equipment	140,565	155,000	155,000
(2) Irradiation services	240,086	765,000	920,000
(3) Special processing, fabrication, and separation and recovery of material	153,391	158,000	158,000
(4) Other services	117,810	139,000	139,000
(e) Security investigations	634,868	613,000	595,000
Total, other costs	6,470,007	6,585,000	5,673,000
2. Related revenue included under program "Revenues applied"	9,996,342	9,372,000	7,544,000
3. Excess of revenue over costs	3,526,335	2,787,000	1,871,000

JUSTIFICATION OF CATEGORIES

1. Other costs, $5,673,000

(*a*) *Cost of special reactor materials, $900,000.*—Includes cost of heavy water sales, principally to foreign countries and cost of boron 10 to domestic users. Decrease of $1,234,000 in fiscal year 1960 from the fiscal year 1959 estimate is due to a reduction in sales of heavy water. Related revenue in amount of $1,794,000 is included under program "Revenues applied."

(*b*) *Cost of isotopes sold, $2,792,000.*—Includes cost of isotopes sold or leased to research laboratories, industry, and educational institutions. The increase of $185,000 from the fiscal year 1959 estimate is related to increased sales of isotopes in fiscal year 1960. Related revenue in amount of $3,444,000 is included under program "Revenues applied."

(*c*) *Cost of other products, $14,000.*—Includes cost of miscellaneous products sold. Related revenue in amount of $17,000 is included under program "Revenues applied."

(*d*) *Cost of services, $1,372,000.*—Includes cost of irradiation services, use of AEC facilities and equipment, special processing and fabrication, separation and recovery of material and other services principally related to research studies. The increase of $155,000 from the fiscal year 1959 estimate is attributable to increased use by industry of irradiation services. Related revenue in amount of $1,632,000 is included under program "Revenues applied."

(*e*) *Cost of security investigations, $595,000.*—Includes cost of security investigations obtained for access permit holders. As a means of encouraging American industry to participate more fully in the atomic energy program, the Commission initiated a program for release of selected classified nonmilitary information, after obtaining the necessary security clearances to applicants who can demonstrate the information is needed in their business or profession. It is estimated that 1,026 limited security clearances and 1,756 full field investigations will be completed during fiscal year 1960 at a total cost of $595,000, and the Commission will accrue approximately $657,000 in revenue from such security investigations. Estimated revenue is included under the program "Revenues applied."

2. Related revenue included under program "Revenues applied", $7,544,000

The estimated total revenue related to the sale of products and services included in the program "Other costs" is $7,544,000 as compared to the cost of the related products and services of $5,673,000 reflecting an excess of revenue over cost of $1,871,000 on the products and services included in this program.

Revenues Applied

Mr. Cannon. Under "Revenues applied" you are requesting $31,415,000. We shall insert pages 252 through 259.

(The pages follow:)

REVENUES APPLIED

Program statement

Estimate fiscal year 1960	$31,415,000
Estimate fiscal year 1959	28,720,000
Increase	2,695,000

The program "Revenues applied" includes the income from sales and lease of products and services to eligible purchasers and other revenue from community operations, tuition income, hospitals and other miscellaneous sources, such as income from royalties and collateral funds. The program "Revenues applied" is presented in two categories on the following schedule of summary of estimates by category. The first category "Revenue from sale of products and services" consists of items for which the related costs are included under the program "Other costs" and the second category "Other revenue" consists of revenue items for which the costs are reflected under the related program costs, and miscellaneous income such as royalty income, and other items of a miscellaneous nature.

Revenue from sale of products and services includes income from sale of special reactor materials, other special material, isotopes and income from use of AEC-owned facilities, irradiation services, processing and fabrication, other miscellaneous services, and income from security investigations. Commission policy provides for full cost recovery for products and services, with the exception of

waiver of use charges for special nuclear materials and heavy water under the cooperative arrangements program as authorized by law, discounts on isotopes used for medical and agricultural research, and other minor exceptions approved by the Commission.

The revenues received are applied in the budget to reduce the appropriation requirements of the Commission.

The increases in revenues of $2,695,000 over the fiscal year 1959 estimate are principally related to increased sales of isotopes, sale and lease of source and special nuclear materials, and increased use of irradiation services. These increases are partially offset by decreases in sales of heavy water, income from schools of reactor technology and decrease in revenue from community operations, due to disposal of housing and commercial properties at Oak Ridge, Tenn., and Richland, Wash.

Summary of estimates by category

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
A. Revenue from sale of products and services (related costs are included under program "Other costs"):			
1. Sale of special reactor materials	$5,422,657	$4,259,000	$1,794,000
2. Sale and lease of isotopes	3,220,713	3,155,000	3,444,000
3. Sale of other products	1,101	17,000	17,000
4. Income from use of AEC-owned facilities and equipment	204,775	222,000	222,000
5. Income from irradiation services	302,992	865,000	1,046,000
6. Income from special processing and fabrication and separation and recovery	201,257	209,000	209,000
7. Income from other services	145,333	155,000	155,000
8. Income from security investigations	497,514	490,000	657,000
Total revenue from sale of products and services	9,996,342	9,372,000	7,544,000
B. Other revenue (related costs are included when applicable under program costs of current or prior years):			
1. Sale of source and special nuclear material	2,289,595	600,000	5,245,000
2. Lease of source, special reactor, and nuclear materials	532,706	1,345,000	2,245,000
3. Income from charges for special nuclear material consumed	164,121	0	302,000
4. Income from sale of steam	309,989	2,200,000	2,200,000
5. Income from research hospitals	355,758	350,000	350,000
6. Income from schools of reactor technology	388,751	380,000	360,000
7. Income from sale of publications and other fees	121,172	90,000	90,000
8. Income from community operations	15,513,868	12,360,000	11,056,000
9. Income from collateral funds	1,172,166	523,000	523,000
10. Other miscellaneous income	1,884,576	1,500,000	1,500,000
Total other revenue	22,732,702	19,348,000	23,871,000
Total revenues applied	32,729,044	28,720,000	31,415,000

JUSTIFICATION OF CATEGORIES

A. Revenue from sale of products and services, $7,544,000

The gross revenue from the sale of products and services in this category for fiscal year 1960 in the amount of $7,544,000 is applied as a reduction of the total appropriation requirement of the Commission; however, it is pertinent to point out that the related costs of these products and services amount to $5,673,000, which is included as an appropriation requirement under the budget program "Other costs." The net revenue after deduction of costs is $1,871,000.

1. *Sale of special reactor materials, $1,794,000.*—This estimate consists principally of revenue from the sale of heavy water to foreign countries for reactor use, also includes domestic sale of minor quantities for research, and sale of minor quantities of Boron 10. The decrease in revenues of $2,465,000 from the fiscal year 1959 estimate is attributable to a reduction in heavy water sales to foreign countries. The related cost of the material is $900,000, which is included in the program "Other costs."

2. *Sale and lease of isotopes, $3,444,000.*—This estimate includes revenue from the sale and lease of stable and radioisotopes to research laboratores, industry, and educational inltitutions. The increase of $289,000 from the fiscal year 1959 estimate is based on increased sales of isotopes in fiscal year 1960. The related cost of the products is $2,792,000, which is included in the program "Other costs."

3. *Sale of other products, $17,000.*—This estimate includes revenue from the sale of miscellaneous products. The related cost of the products is $14,000, which is included under the program "Other costs."

4. *Income from use of AEC-owned facilities and equipment, $222,000.*—This estimate includes income derived principally from use of Commission laboratory facilities for research work. Cost of services included under program "Other costs" is estimated to be $155,000.

5. *Income from irradiation services, $1,046,000.*—This revenue is derived principally from irradiation services for research and industrial application performed at the national reactor testing station. The increase of $181,000 from the fiscal year 1959 estimate is based on past experience which has indicated a steady growth in the number of experiments conducted since the startup of the testing station. Related cost of services included under program "Other costs" is estimated to be $920,000.

6. *Income from special processing and fabrication and separation and recovery, $209,000.*—This estimate consists principally of revenues derived from special processing and fabrication services performed by the Oak Ridge office. Related cost of services included under program "Other costs" is estimated to be $158,000.

7. *Income from other services, $155,000.*—This estimate consists principally of revenues derived from services related to use of Commission laboratory services and equipment. Related cost of services included under program "Other costs" is estimated to be $139,000.

8. *Income from security investigations, $657,000.*—This estimate covers income from authorized access permitholders for charges for security investigations. As a means of encouraging American industry to participate more fully in the atomic energy program, the Commission has instituted a program for release of selected classified nonmilitary information, after obtaining the necessary security clearances, to applicants who can demonstrate the information is needed in their business or profession. The estimated revenue is based on charging for all security investigations, with the exception of those for nonprofit educational institutions. On this basis, it is estimated that 5 percent of the security investigations in fiscal year 1960 will be provided without charge. The related cost for security investigations included under the program "Other costs" is $595,000.

B. Other revenue, $23,871,000

1. *Sale of source and special nuclear material, $5,245,000.*—This estimate includes revenue from sale of normal and enriched uranium to foreign countries, and domestic sale of normal and depleted uranium for industrial and research usage. Increase of $4,645,000 from the fiscal year 1959 estimate is based on additional sales to foreign and domestic sources. Related costs of the products were included in program costs in prior years.

2. *Lease of source, special reactor and special nuclear materials, $2,245,000.*—Current Commission policy provides for the lease of heavy water, for other than power reactors, and other materials to foreign countries and domestic users at a lease charge of 4 percent per annum. In certain cases it is anticipated that material will be sold to foreign countries rather than leased. The estimate includes the following income:

(*a*) Domestic	$1, 538, 000
(*b*) Foreign	707, 000
Total	2, 245, 000

The revenue from domestic sources is principally related to lease of enriched materials for power reactors generating a revenue of approximately $1,177,000; materials leased for research and test reactors are estimated to provide a revenue of approximately $241,000; and additional revenue of approximately $120,000 is anticipated from the lease of normal uranium, plutonium, and heavy water for research purposes. The revenue from foreign sources is related to lease of enriched materials for power reactors and research purposes of approximately $413,000 and lease of heavy water of approximately $294,000. It is not anticipated that the Commission will purchase any plutonium during fiscal year 1960 produced from leased materials or materials sold to foreign countries. Estimates are subject to adjustment dependent upon accomplishment of program scheduling by users of material.

3. *Income from charges for special nuclear material consumed, $302,000.*—This estimate includes revenue for charges for material consumed in reactor operations by military users. Current agreements with the Department of Defense provide

that the Commission will be reimbursed for materials consumed in military reactors.

4. *Income from sale of steam, $2,200,000.*—This estimate consists of revenue from the sale of steam from the pressurized water reactor at Shippingport to the Duquesne Power & Light Co. and from the sodium reactor experiment (SRE) at Santa Susana, Calif., to the Southern California Edison Co. The fiscal year 1960 estimate assumes a continuation of the fiscal year 1959 revenue level.

5. *Income from research hospitals, $350,000.*—This estimate includes income from patients at the Commission's research hospitals. Related costs for the operation of the hospitals are included under the Biology and Medicine program, together with the costs of operation of the Cancer Research Laboratories and related facilities.

6. *Income from schools of reactor technology, $360,000.*—This estimate includes revenue for tuition from students attending the Argonne International School of Nuclear Science and Engineering at Chicago, the reactor supervisor course at Shippingport, Pa., and the reactor hazards evaluation and reactor supervisor courses at Oak Ridge. The related costs for the schools are included under program costs. The net decrease in revenues of $20,000 from the fiscal year 1959 estimate is based on—

(*a*) A decrease of $120,000 as the result of discontinuing the prerequisite courses to the Argonne School which were held at Pennsylvania State University and North Carolina State College under contract with AEC and for which AEC charged tuition. This discontinuance is based on the courses now being available at a number of universities.

(*b*) An increase of $100,000 in the estimated revenues from the reactor supervisor courses at Shippingport, Pa.

7. *Income from sale of publications and other fees, $90,000.*—This estimate includes income from the sale of pamphlets to museum visitors, sale of classified technical publications to access permit holders, and sale of unclassified technical publications to the Department of Commerce for resale to the public. Related costs are included under program costs.

8. *Income from community operations, $11,056,000.*—This estimate includes the income from the AEC communities of Oak Ridge, Tenn.; Richland, Wash.; Los Alamos and Sandia, N. Mex., and the Utah community. Aggregate income includes revenue from housing and commercial properties, including hospitals, income from municipal services, utility operations, and other miscellaneous sources. The community program schedules, included under the community program, reflect the revenue by community and category. Related costs of $15,666,000 are included under program costs. The decrease in community revenue of $1,304,000 from the fiscal year 1959 estimate is due principally to the projected disposal of housing, commercial and utility properties at Oak Ridge, Tenn., and Richland, Wash.

9. *Income from collateral funds, $523,000.*—This estimate includes income from collateral funds held by contractors for insurance collateral, employee benefits, and annuity funds.

10. *Other miscellaneous income, $1,500,000.*—This estimate includes income from royalties, insurance indemnity fees, and other miscellaneous sources of a general nature and is based on continuation of the fiscal year 1959 level.

Selected Resources

Mr. Cannon. Under "Selected resources" you are requesting $960,944,384. We shall insert pages 260 through 277.

(The pages follow:)

Increase or Decrease In Selected Resources

Program statement

Estimate, fiscal year, 1960	$960, 944, 384
Estimate, fiscal year 1959	900, 038, 384
Increase	60, 906, 000

This program, "Increase or decrease in selected resources," presents the net increase or decrease in levels of resources required to support the programs of the Commission. This program includes requirements for inventories, collateral funds and other deposits, and goods and services on order. The category "Goods

and services on order" includes contracts for materials and services to be delivered after fiscal year 1960 and financing of contractors in accordance with Commission policy beyond the end of the fiscal year to insure continuity of operations. The contractor requirements included in the estimate provide for 3 months of forward financing. The levels of selected resources are assets that may be applied to program costs of future years' operations.

The estimate of $60,906,000 for fiscal year 1960 consists of $782,000 to finance increases in inventory levels and an increase of $60,124,000 in the level of goods and services on order.

The net increase in inventory levels of $782,000 consists of—

1. An increase in stores inventory of $1 million to fund an inventory level which is related to increased cost levels in the reactor development program and increased operating levels of weapons production contractors.

2. An increase of $1,500,000 for isotopes inventory required to support increased research activity and provide a higher inventory level of items for sale and lease to industrial and research users.

3. Decrease in the special reactor materials and other special materials inventories of $676,000 and $1,042,000, respectively.

The increase in level of goods and services on order is related to program costs levels at the end of fiscal year 1960.

Summary of estimates by category

Balances at end of year	Actual, 1958	Estimate, 1959	Estimate, 1960	Increase or decrease (−)
1. Inventories:				
(a) Stores	$89,536,924	$90,537,000	$91,537,000	$1,000,000
(b) Special reactor materials	73,124,727	80,022,000	79,346,000	−676,000
(c) Other special materials	18,067,442	17,417,000	16,375,000	−1,042,000
(d) Isotopes	5,905,089	6,797,000	8,297,000	1,500,000
Total inventories	186,634,182	194,773,000	195,555,000	782,000
2. Collateral funds and other deposits	21,006,725	20,677,000	20,677,000	0
3. Goods and services on order	655,988,527	684,588,384	744,712,384	60,124,000
Total unapplied resources at end of year	863,629,434	900,038,384	960,944,384	60,906,000
Increase or decrease in selected resources	77,284,228	36,408,950	60,906,000	

JUSTIFICATION OF CATEGORIES

1. Inventories, increase, $782,000

(a) *Stores inventory, increase $1 million.*—Stores inventories are supplies, materials, and parts normally used or consumed in the production of source and special nuclear materials; in the maintenance of production plants, buildings, and other facilities; or in the operation of laboratories and experimental projects, communities and administrative activities. Stores exclude source and special nuclear materials, weapons components, special reactor materials, and other special materials.

The net increase of $1 million in the total level of stores inventory for fiscal year 1960 is attributable to an increase of $1,040,000 for reactor development contractors related to increased costs levels and $990,000 for weapons contractors principally due to the variety of materials which they will be required to maintain. These increases are partially offset by decreases of $1,030,000 in operating inventories of special nuclear materials contractors.

(b) *Special reactor materials inventory, decrease, $676,000.*—This inventory consists of selected materials used in the construction and operation of reactors for production and research purposes.

The decrease is related principally to termination of procurement contracts as a result of reductions in program requirements.

A classified schedule of the inventory levels of special reactor materials is presented on classified page 270.

(c) *Other special materials, decrease, $1,042,000.*—Other special materials inventory is made up of the following items, requiring special accounting controls. Radium, gold, silver, platinum, rhodium, palladium, iridium, osmium, gallium, and barrier items.

The decrease is primarily attributable to a reduction in the inventory level for barrier items.

(*d*) *Isotopes, increase, $1,500,000.*—The increase in the inventory levels of isotopes is indicated below:

	Estimate, fiscal year 1959	Estimate, fiscal year 1960	Increase
Stable isotopes	$3,405,000	$4,559,000	$1,154,000
Radioisotopes	3,392,000	3,738,000	346,000
Total inventory	6,797,000	8,297,000	1,500,000

Of the increase in the stable isotopes inventory, $0.6 million is related to the general increase in research programs and there is also an additional increase of approximately $0.6 million required to meet the specific needs of cross-section measurements activities. The increase of $0.3 million in the radioisotopes inventory is related to increased levels for sales.

2. Collateral funds and other deposits, no increase

No change is planned in fiscal year 1960 for collateral funds and other deposits. The fiscal year 1960 year-end balance includes $18,680,000 for collateral funds consisting of insurance collateral funds, employee benefit and annuity funds; and $1,997,000 in other deposits required by vendors on containers and other deposits of a miscellaneous nature. The collateral funds were established under contracts originally entered into by the War Department, and were designed to provide for various extraordinary contingencies in the activities of cost-type contractors. For the most part, collateral funds are held by trustees and invested in U.S. Government securities.

The following table indicates the balances of collateral funds and other deposits as of the end of fiscal years 1958, 1959, and 1960:

Collateral funds and other deposits balance at close of year	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Collateral funds by office and contract:			
Hanford, Wash.: General Electric insurance fund, Travelers Insurance Co	$10,500,000	$10,500,000	$10,500,000
Albuquerque, N.Mex.: Los Alamos University of California employees benefit fund	1,000,000	1,000,000	1,000,000
San Francisco, Calif.: Berkeley, University of California employees benefit fund	480,000	480,000	480,000
Chicago, Ill.: University of Chicago employees benefit fund	500,000	500,000	500,000
New York, N.Y.: Columbia University employees benefit fund	200,000	200,000	200,000
Washington, D.C.: University of California, Los Alamos, and University of Chicago insurance fund, Royal & Glove Co	6,000,000	6,000,000	6,000,000
Total collateral funds	18,680,000	18,680,000	18,680,000
Other deposits	2,326,725	1,997,000	1,997,000
Total collateral funds and other deposits	21,006,725	20,677,000	20,677,000

3. Goods and services on order, increase, $60,124,000

Estimates for fiscal year 1960 are are based on Commission policy of 3 months forward financing for cost reimbursement type contractors and funding of commitment levels at the end of the contract period to insure continuity of operations. The funding requirements are related to the cost levels presented under program costs. The increase in the level of goods and services on order is related primarily to (1) production of weapons to meet military needs, (2) higher operating levels of research and development for the expanding reactor development program, (3) an increase for space in test and power reactors, and (4) an increase for the cooperative arrangements program (civilian power reactors). These increases are offset partially by reductions in cancellation liabilities for major material procurement contracts.

A summary table of requirements by category is included on the following table:

[In thousands]

Year-end balances, goods, and services on order	Fiscal year 1958 actual	Fiscal year 1959 estimate	Fiscal year 1960 estimate	Increase or decrease
1. Major long-term reimbursement contracts (over $1,000,000 annual operating level):				
(a) Production of source and special nuclear materials	$164,069	$150,013	$150,903	+$890
(b) Production of weapons and weapon components	118,423	101,369	106,867	+5,498
(c) Research and development	225,252	266,000	281,514	+15,514
(d) Supporting services	16,634	18,180	8,080	−10,100
Total	524,378	535,562	547,364	+11,802
2. Major material procurement contracts	60,000	37,376	26,420	−10,956
3. Research and development contracts (other than those contracts included under item 1(c))	30,426	38,743	80,386	+41,643
4. Cooperative arrangements program (civilian power reactors)	19,907	43,818	62,455	+18,637
5. Utilities	3,260	2,490	2,259	−231
6. All other	18,018	26,599	25,828	−771
Grand total	655,989	684,588	744,712	+60,124

1. Major long-term reimbursement contracts (over $1 million annual operating level), increase $11,802,000

The estimates provide forward financing of 3 months in addition to financing the level of outstanding commitments at the end of this period. Increases or decreases by category of contracts are listed on the following page.

(a) *Production of source and special nuclear materials, increase, $890,000.*—Reflects higher costs of production.

(b) *Production of weapons and weapons components, increase, $5,498,000.*—This increase is related to production of weapons to meet military requirements.

(c) *Research and development, increase, $15,514,000.*—This increase is related principally to—

(1) Higher levels of research and development on the civilian power reactor program, and on research and development on reactor systems, reactor safety, radioactive waste systems development, and the natural circulation reactor.

(2) Increased level of effort on the physical research program.

(3) Increased level of effort on research and development for nonnuclear weapon components.

(d) *Supporting services, decrease, $10,100,000.*—This decrease is related principally to a reduction in levels for test contractors as a result of the suspension of tests.

2. Major material procurement contracts, decrease, $10,956,000.

This decrease is related principally to reduction of cancellation liabilities on contracts for materials procurement, a reduction in the Combined Development Agency assets liquidated against projected deliveries of raw materials and a reduction in working capital advances to Canadian mine operators.

3. Research and development, increase, $41,643,000

This increase is related principally to—

	Millions
(a) Contracts for space in test and power reactors	$27.5
(b) Increase for the Euratom program	4.5
(c) Contracts for research and development in the areas of the merchant ship reactor program, reactor systems, reactor safety, and radioactive residues managemnt, as well as for civilian power reactor experiment fabrication	5.5
(d) Contracts for studies on organic materials and sodium components	1.2
(e) Increased research and development on the Army power reactors program	1.4
(f) Procurement of research equipment	.9

4. Cooperative arrangments program (civilian power reactors), increase, $18,637,000

The followng table reflects the levels of uncosted balances at the end of the fiscal year under various contracts in the cooperative arrangements program for the advancement of civilian nuclear power:

	Year-end balances (in thousands)			Increase or decrease (−) in fiscal year 1960
	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960	
Fiscal year 1958 cooperative power reactor demonstration program:				
Yankee Atomic Electric Co	$1,647	$247	0	−$247
Consumers Public Power District	8,000	8,500	$8,500	0
R. & D. on fast breeder technology	223	523	523	0
Elk River-Rural Cooperative Power Association	2,176	2,176	2,076	−100
City of Puqua, Ohio	145	3,513	3,513	0
Chugach Electric Association of Alaska	2,218	0	0	0
Northern States Power Co	5,498	6,698	4,198	−2,500
Carolinas-Virginia Nuclear Power Association, Inc	0	12,723	10,123	−2,600
East Central and Florida Westcoast Nuclear Group	0	8,597	8,981	+384
Unapplied R. & D. funds	0	841	841	0
Fiscal year 1960 cooperative power reactor demonstration program:				
Boiling water prototype	0	0	2,150	+2,150
Intermediate size prototype reactor	0	0	6,650	+6,650
R. & D. assistance for unsolicited proposals	0	0	3,500	+3,500
Advanced high temperatire reactor (Philadelphia Electric)	0	0	11,400	+11,400
Total	19,907	43,818	62,455	+18,637

5. Utility contracts, decrease, $231,000

This decrease represents a reduction in the cancellation liability under the contract with the East Tennessee Natural Gas Co. for the supply of gas at Oak Ridge, Tenn.

6. All other, decrease, $771,000

This decrease represents a reduction in the level of AEC obligations for miscellaneous contracts.

SPECIAL SUMMARY INFORMATION

All Programs—AEC Direct Employment

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Number of permanent full-time civilian employees at end of fiscal year	6,865	6,800	6,921
Average number of permanent full-time civilian employees	6,749	6,816	6,861
Total personal services costs	$46,800,082	$51,254,000	$52,750,000

It is the basic policy of the Commission to conduct the atomic energy program through contractors to the greatest practical extent. The following functions are performed by AEC employees within this basic policy: (1) Program planning and direction, contract negotiation, liaison with contractors and inspection of contractor products; (2) administration of industrial development, licensing and international cooperation activities; (3) security measures including screening of personnel, protection of documents and property, guarding of security shipments and patrolling of sites where contractor guard service is not provided; (4) evaluation of domestic and foreign raw materials resources; (5) operation of storage sites; (6) operation of the New Brunswick Laboratory and New York Health and Safety Laboratory; (7) operation and management of the Los Alamos communications facilities, and fire and police department; (8) operation of health and safety activities at the national reactor testing station in Idaho; (9) accounting, auditing, property management, and personnel services, assuring adequate controls by

AEC offices and contractors; (10) control and dissemination of scientific and technical information; and (11) provision of supporting services at the AEC headquarters and field offices.

The fiscal year 1960 estimate provides for an increase of 121 permanent full-time employees over the June 30, 1959, end strength of 6,800. Yearend strengths and average employment for permanent full-time employees and total personal services costs for each of the Commission's programs are shown in the following table:

Program	Actual, fiscal year 1958			Estimate, fiscal year 1959			Estimate, fiscal year 1960		
	Employment		Costs (in thousands)	Employment		Costs (in thousands)	Employment		Costs (in thousands)
	End strength	Average full time		End strength	Average full time		End strength	Average full time	
Raw materials	177	205	$1,402	167	172	$1,413	162	164	$1,364
Special nuclear materials	181	182	1,200	182	180	1,287	182	182	1,327
Weapons	1,081	1,088	6,369	1,101	1,084	6,882	1,101	1,101	7,194
Reactor development	207	193	1,182	216	210	1,365	221	219	1,448
Biology and medicine	85	83	612	88	86	712	88	88	736
Training, education, and information	182	177	937	182	182	1,040	182	182	1,056
Community	123	124	747	115	120	792	115	115	780
Program direction and administration	4,829	4,697	34,351	4,749	4,782	37,763	4,870	4,810	38,845
Total	6,865	6,749	46,800	6,800	6,816	51,254	6,921	6,861	52,750

The net increase of 121 employees is attributable to increased workload in program direction and administration as outlined in the justification for operating costs under that program. No change in total requirements is requested for the other programs. An increase of five employees in the reactor development program to man an added fire station at the Idaho National Reactor Testing Station is offset by a reduction of five employees in the raw materials program engaged in domestic raw materials resources evaluation activities.

ALL PROGRAMS, TRAVEL

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Estimated number of travel days	106,272	118,522	126,336
Total estimated cost	$2,992,777	$3,280,000	$3,550,000

This estimate covers the cost of official travel of Government employees while discharging assigned AEC duties away from official duty stations. It is pointed out that the number of travel days and the travel costs reflect the travel of three principal classes of personnel: (1) AEC permanent full-time employees, (2) AEC intermittent employees such as members of advisory groups and individual consultants, and (3) about 250 military personnel on duty with the AEC, whose salaries are paid by the Department of Defense, but whose duties require considerable travel on AEC business. Some employees of the Commission spend the major part of their duty time away from their official station, such as shipment security guards in the special nuclear materials, weapons, and reactor development programs. Extensive travel is required in connection with weapons production, quality assurance inspections and storage activities under the weapons program; inspection of licensed facilities; international cooperation activities; and the industrial program. Substantial travel is also required to maintain a satisfactory degree of technical and administrative supervision over Commission offices and projects and liaison with contractors, to provide for attendance of technical and scientific personnel at important domestic and foreign conferences and symposia, and to provide for coordination of and participation in oversea nuclear energy exhibits.

The fiscal year 1960 request represents the estimated requirements for travel essential to the proper discharge of Commission responsibilities in all areas. The estimate for the raw materials program is related directly to the scope of the domestic and foreign resource evaluation programs. The estimates for the special nuclear materials and reactor development programs are geared to the volume of security shipments requiring escort personnel. The estimate for the weapons program is related to the projected level of operating costs in fiscal year 1960 which will necessitate a high volume of travel, especially in the quality assurance program and in providing escort personnel for security shipments. The travel requested under the biology and medicine program is for required travel of personnel assigned to the New York Health and Safety Laboratory. A small amount of travel funds is required under the training, education, and information program by the Technical Information Service Extension at Oak Ridge. Under the community program limited travel is performed by personnel engaged in community operations under the Oak Ridge, Hanford, and Albuquerque Operations Offices. The estimate for program direction and administration was discussed in the justification for operating costs of that program.

The following table reflects a comparison of the estimated days of travel and estimated costs of the various programs:

[Costs, in thousands]

Program	Actual, fiscal year 1958		Estimate, fiscal year 1959		Estimate, fiscal year 1960	
	Days	Cost	Days	Cost	Days	Cost
Raw materials	11,209	$139	11,595	$193	11,505	$190
Special nuclear materials	6,576	168	9,384	199	9,384	199
Weapons	15,788	343	29,573	541	31,917	586
Reactor development	2,327	53	5,419	103	5,319	109
Biology and medicine	1,140	41	1,395	54	1,395	54
Training, education, and information	150	5	151	6	151	6
Community	161	3	213	6	213	6
Program direction and administration	68,921	2,241	60,792	2,178	66,452	2,400
Total	106,272	2,993	118,522	3,280	126,336	3,550

STATEMENT ON PASSENGER CARRYING MOTOR VEHICLES

	Actual, 1958	Estimated, 1959	Estimated, 1960
Net active fleet end of fiscal year	2,098	2,114	2,144
Number of replacement vehicles	460	435	366
Number of additional vehicles	0	0	30
Gross cost of replacement vehicles	$1,180,637	$1,474,258	$781,369
Gross cost of additional vehicles	0	0	$359,100
Total gross cost of vehicles	$1,180,637	$1,474,258	$1,140,469

Passenger motor vehicles are required by the AEC for security patrols of extensive plant and laboratory areas, management and administration of AEC-owned communities, inspection and audit of Commission and contractor-operated facilities, and for other necessary official transportation of AEC and contractor personnel within and between project sites and areas in the management and operation of the programs conducted by the agency.

Table A, below, shows the passenger motor vehicles requirements, by type, for fiscal year 1960. The estimate includes requirements for both contractor operations and the AEC. The additional vehicle requirements are attributable to the expanding operations at the Idaho test site with the exception of one 15-passenger Metro-type bus which is required at Schenectady to transport personnel to and from the West Milton site. All vehicles to be replaced meet or exceed the GSA replacement standards. A breakdown of the AEC fleet is shown in table B.

TABLE A.—*Passenger motor vehicle requirements*

	Actual, fiscal year 1958		Estimate, fiscal year 1959		Estimate, fiscal year 1960	
	Number	Cost	Number	Cost	Number	Cost
Automobiles	377	$546,175	372	$614,050	335	$553,834
Station wagons	41	80,671	21	43,850	20	42,475
Ambulances	3	7,938	9	54,625	3	15,800
Buses	39	545,853	33	761,733	38	528,360
Total requirements	460	1,180,637	435	1,474,258	396	1,140,469

TABLE B.—*Net active fleet of passenger motor vehicles at end of year*

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Automobiles	1,499	1,510	1,526
Station wagons	128	121	121
Ambulances	54	54	55
Buses	417	429	442
Total	2,098	2,114	2,144

The increase in the inventory level from fiscal year 1958 to fiscal year 1959 is attributable to vehicles disposed of in late fiscal year 1958 to be replaced by vehicles in the fiscal year 1959 procurement program. The Atomic Energy Commission has an active program to promote more effective utilization of equipment, principally through increased use of AEC and GSA motor pools, and through this program has been able to maintain its fleet of passenger motor vehicles at a fairly constant level even though operating programs have continued to expand.

Mr. CANNON. Tell us something about the increase in Selected Resources.

Mr. MCCARTHY. This is the amount necessary to fund our major contracts during the first 3 months of the new fiscal year, as we mentioned the other day. It also includes inventories of our various stores and supplies in the hands of our contractors. Each year we budget for the change in the balance, which this year is an increase of $60 million. The major part of the year-end balance of $961 million, that is $745 million, will be obligated and under contract but not costed at the end of fiscal 1960. The remaining $216 million principally represents inventories on hand at the end of the fiscal year.

Mr. CANNON. I was a little concerned because you increase that a little over $60 million. Is that increase fully justified?

Mr. MCCARTHY. Yes, sir; it is in line with the growing program.

PLANT ACQUISITION AND CONSTRUCTION

GENERAL STATEMENT

BUDGET SUBMISSION, JANUARY 1959

Program and financing

	1958 actual	1959 estimate	1960 estimate
Program by activities:			
Facilities for—			
1. Raw materials	$745,381	$416,756	
2. Special nuclear materials	35,090,845	132,094,093	$75,000,000
3. Weapons	48,374,322	58,085,230	
4. Reactor development	100,866,621	210,516,286	18,800,000
5. Physical research	14,772,545	55,646,197	19,025,000
6. Biology and medicine	1,245,068	2,339,702	
7. Training, education, and information	2,710,965	1,789,035	
8. Isotopes development		1,600,000	
9. Communities	5,206,757	2,785,745	
10. Administration	4,073,301	650,438	
Total obligations	213,085,805	465,923,482	112,825,000
Financing:			
Unobligated balance brought forward	−308,028,598	−222,864,482	−10,825,000
Unobligated balance transferred from "Access roads, act of Sept. 7, 1950, Bureau of Public Roads" (67 Stat. 187)	−341,189		
Recovery of prior year obligations	−19,418,000	−3,955,000	
Unobligated balance carried forward	222,864,482	10,825,000	
Appropriation (new obligational authority)	108,162,500	249,929,000	102,000,000

Object classification

		Actual, 1958	Estimate, 1959	Estimate, 1960
	ATOMIC ENERGY COMMISSION			
03	Transportation of things	$226,287	$506,000	
04	Communication services		15,000	
07	Other contractual services	16,923,542	10,407,000	
	Services performed by other agencies	62,109		
08	Supplies and materials	120,683	150,000	
10	Lands and structures	184,182,359	439,910,224	112,825,000
11	Grants, subsidies, and contributions	26,931	30,000	
	Total obligations	201,541,911	451,018,224	112,825,000
	Allocation from "Plant acquisition and construction, Atomic Energy Commission"			
	Total number of permanent positions	13	7	
	Full-time equivalent of all other positions	2		
	Average number of all employees	10	7	
	Number of employees at end of year	6	7	
	Average GS grade and salary	6.4 $5,033	5.9 $5,120	
01	Personal services:			
	Permanent positions	$36,625	$31,865	
	Positions other than permanent	9,336		
	Other personal services	295	222	
	Total personal services	46,256	32,087	
02	Travel	5,357	4,500	
03	Transportation of things	4,666	20,000	
04	Communication services	250	200	
05	Rents and utility services	7,920	525	
06	Newspapers and periodicals	181	25	
07	Other contractual services	566,580	221,575	
08	Supplies and materials	2,289,149	11,676,812	
10	Lands and structures	8,621,381	2,947,441	
11	Grants, subsidies, and contributions	2,001	2,093	
15	Taxes and assessments	153		
	Total obligations, allocations from the Atomic Energy Commission	11,543,894	14,905,258	
	Grand total obligations	213,085,805	465,923,482	112,825,000
	Obligations are distributed as follows:			
	Atomic Energy Commission	201,541,911	451,018,224	112,825,000
	Department of Agriculture: Soil Conservation Service	55,688	15,067	
	Department of Commerce:			
	Bureau of Public Roads	697,457	115,169	
	Maritime Administration	7,037,422	1,297,578	
	Department of the Interior: Bureau of Indian Affairs	20,921	1,587	
	Department of the Navy	5,494		
	General Services Administration	2,284,520	11,700,000	
	Department of the Army	1,442,392	1,775,857	

Proposed for later transmission under proposed legislation

	1958 actual	1959 estimate	1960 estimate
Program by activities:			
Facilities for:			
1. Raw materials			$200,000
2. Special nuclear materials			40,960,000
3. Weapons			24,433,000
4. Reactor development			35,350,000
5. Physical research			15,650,000
6. Biology and medicine			2,382,000
7. Isotopes development			3,400,000
8. Training, education, and information			150,000
9. Communities			2,775,000
10. Administration			700,000
Total obligations			126,000,000
Financing: Proposed suplemental appropriation (new obligational authority)			126,000,000

REVISED BUDGET (H. DOC. 179), JUNE 18, 1959

Program and financing

	Original estimates	Revised estimates	Increase or decrease (−)
Program by activities:			
Facilities for:			
1. Raw materials		$100,000	$100,000
2. Special nuclear materials	$75,000,000	149,880,000	74,880,000
3. Weapons		34,141,000	34,141,000
4. Reactor development	18,800,000	161,914,000	143,114,000
5. Physical research	19,025,000	64,899,000	45,874,000
6. Biology and medicine		3,382,000	3,382,000
7. Training, education, and information		1,025,000	1,025,000
8. Civilian application of isotopes and nuclear explosives		3,400,000	3,400,000
9. Communities		2,775,000	2,775,000
10. Administrative		700,000	700,000
Total program (obligations)	112,825,000	422,216,000	309,391,000
Financing: Unobligated balance brought forward	−10,825,000	−152,216,000	−141,391,000
Appropriation (new obligational authority)	102,000,000	270,000,000	168,000,000

Object classification

	Original estimate	Revised estimate	Increase or decrease (−)
Lands and structures	$112,825,000	$422,216,000	$309,391,000

Mr. CANNON. Taking up the last book, "Plant acquisition and construction" will you give us a general statement on this?

We shall insert pages 278 through 284.

(The pages follow:)

General Statement

SUMMARY OF REQUIREMENTS FOR FISCAL YEAR 1960

The budget estimates for the appropriation plant acquisition and construction for the fiscal year 1960 provide for total obligations of $422,216,000 of which funds in the amount of $152,216,000 are presently available from prior year appropriations, requiring a new appropriation of $270 million.

Of the total amount of funds presently available, namely, $128,711,000 is required for prior year projects which were not fully contracted for in fiscal year 1959. The remainder of the funds presently available, $23,505,000 is a net unobligated balance resulting from the elimination, or deferment beyond fiscal year 1960, of projects or changes in the total estimated cost of projects for which funds were previously appropriated.

The prior year projects which have not been fully contracted and for which $128,711,000 of funds presently available are carried forward for obligation in fiscal year 1960 are identified in section B under each program throughout this document. The newly authorized projects and residual funding of previously authorized projects requiring obligation of $293,505,000 in fiscal year 1960, which are to be funded by the new appropriation of $270 million and the $23,505,000 of funds presently available are identified in section A under each program throughout this document.

A summarization of the fiscal year 1960 obligations by program, showing the application of funds presently available and the derivation of the new appropriation requirement follows.

Summary of obligations for fiscal year 1960 by program

Program	Fiscal year 1960 obligations		
	Sec. A (funding)	Sec. B (carryover)	Total
Raw materials	$100,000	0	$100,000
Special nuclear materials	115,960,000	$33,920,000	149,880,000
Weapons	21,633,000	12,508,000	34,141,000
Reactor development	93,650,000	68,264,000	161,914,000
Physical research	51,755,000	13,144,000	64,899,000
Biology and medicine	3,382,000	0	3,382,000
Training, education, and information	150,000	875,000	1,025,000
Civilian applications of isotopes and nuclear explosives	3,400,000	0	3,400,000
Community	2,775,000	0	2,775,000
Administrative	700,000	0	700,000
Total obligations	293,505,000	128,711,000	422,216,000
Unobligated balances brought forward	23,505,000	128,711,000	152,216,000
Appropriation	270,000,000	0	270,000,000

THREE-YEAR SUMMARY OF OBLIGATIONS AND FINANCING OF OBLIGATIONS

The following tables summarize the total obligations incurred for each of the AEC's major construction programs for fiscal year 1958, fiscal year 1959, and fiscal year 1960, and the sources of funding these obligations:

Summary of obligations by program

Program	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Raw materials	$745,381	$216,756	$100,000
Special nuclear materials	35,090,845	81,689,093	149,880,000
Weapons	48,374,322	48,130,230	34,141,000
Reactor development	100,866,621	162,977,286	161,914,000
Physical research	14,772,545	43,586,197	64,899,000
Biology and medicine	1,245,068	2,600,702	3,382,000
Training, education, and information	2,710,965	914,035	1,025,000
Civilian applications of isotopes and nuclear explosives	0	0	3,400,000
Community	5,206,757	2,785,745	2,775,000
Administrative	4,073,301	650,438	700,000
Total obligations	213,085,805	343,550,482	422,216,000

Summary of financing

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Funds available:			
Unobligated balance at beginning of year	$308,028,598	$222,864,482	$152,216,000
Recovery of prior year obligations	19,418,000	22,973,000	0
Appropriations	108,162,500	249,929,000	270,000,000
Unobligated balance transferred from "Access roads, act of Sept. 7, 1950, Bureau of Public Roads" (67 Stat. 187)	341,189	0	0
Net amount available for obligations	435,950,287	495,766,482	422,216,000
Less unobligated balance at end of year	222,864,482	152,216,000	0
Obligations	213,085,805	343,550,482	422,216,000

Expenditures for plant acquisition and construction

Expenditures for plant acquisition and construction for fiscal year 1960 are estimated to be $298 million, an increase of $58 million over the estimate of $240 million in fiscal year 1959. Actual expenditures in fiscal year 1958 totaled $212,520,074. Unexpended balances are expected to decrease from $584,225,965 at the beginning of fiscal year 1958 to an estimated $462,138,500 at the end of fiscal year 1960 as shown in the following table which depicts the amounts available for expenditure and the expenditures for each year, and the unexpended balances at the end of each year.

	Actual, fiscal year 1958	Estimate, fiscal year 1959	Estimate, fiscal year 1960
Unexpended balance, beginning of year	$584,225,965	$480,209,580	$490,138,580
Appropriation	108,162,500	249,929,000	270,000,000
Transfer from Public Roads	341,189	0	0
Total Funds available	692,729,654	730,138,580	760,138,580
Less: Expenditures	212,520,074	240,000,000	298,000,000
Unexpended balance, end of year	480,209,580	490,138,580	462,138,580

Highlights of construction programs

As shown in the table on page 279, estimates are presented for construction requirements for each of the AEC's functional programs. The highlights of the estimates for new projects for which appropriation requests have been deferred until fiscal year 1960 are as follows (sec. A obligations):

1. *Raw materials.*—Obligations for raw materials facilities in fiscal year 1960 are estimated at $0.1 million to provide for minor modifications and improvements to existing plant or installations of the Grand Junction, Colo., operations office.

2. *Special nuclear materials.*—Obligations for special nuclear materials facilities in fiscal year 1960 are estimated at $116 million to provide $75 million for continuation of construction of a graphite-moderated, water-cooled, plutonium production reactor designed for future conversion to power production, $16.6 million for production reactor improvements, $4 million for prototype and supporting installations at gaseous diffusion plants, $10 million for modifications to production and supporting installations, and $10.4 million for general plant projects.

3. *Weapons.*—Obligations for weapons facilities in fiscal year 1960 are estimated at $21.6 million to provide $12.1 million for additional production capacity and research and development facilities, $1.5 million for storage site modifications, and $8 million for general plant projects.

4. *Reactor development.*—Obligations for reactor development facilities in fiscal year 1960 are estimated at $93.7 million to provide $43.8 million for construction and modification of reactors and reactor experiments for the civilian power program, including $25 million for the cooperative power reactor demonstration program, $6 million for an experimental organic-cooled reactor, and $5 million for alterations to the Shippingport reactor facilities; $31.8 million related to military reactor and test projects; $10.6 million for modifications and additions

to general support facilities and for hot cells; and $7.5 million for general plant projects for the reactor development program.

5. *Physical research.*—Obligations for physical research facilities in fiscal year 1960 are estimated at $51.8 million to provide $25.4 million for construction of accelerators, including $15.5 million to complete construction of the high energy accelerator at Argonne National Laboratory and $5 million to complete construction of the high energy accelerator at Brookhaven National Laboratory; $12.8 million for research reactors; $7.6 million for research laboratories; $3.5 million for modifications and additions to existing research machines and laboratories; and $2.5 million for general plant projects.

6. *Biology and medicine.*—Obligations for biology and medicine facilities are estimated at $3.4 million to provide $3 million for the construction of facilities for support of biomedical research projects in atomic energy, and $0.4 million for general plant projects.

7. *Training, education and information.*—Obligations for training, education, and information facilities in fiscal year 1960 are estimated at $0.2 million to provide for general plant construction at the nuclear training center in Puerto Rico.

8. *Civilian applications of isotopes and nuclear explosives.*—Obligations for civilian applications of isotopes and nuclear explosives facilities in fiscal year 1960 are estimated at $3.4 million to provide $3.1 million for two radioisotope development laboratories, and $0.3 million for expansion and modifications to the radioisotope production area at Oak Ridge National Laboratory.

9. *Community.*—Obligations for community facilities in fiscal year 1960 are estimated at $2.8 million to provide $1 million for general plant projects at Oak Ridge, Hanford, Los Alamos, and Sandia; and the following projects at Los Alamos: $0.5 million for school additions; $0.3 million for real estate development; and $1 million for housing modifications.

10. *Administrative.*—Obligations for administrative facilities in fiscal year 1960 are estimated at $0.7 million for general plant projects.

EXPLANATION OF PROPOSED LANGUAGE CHANGES—PLANT ACQUISITION AND CONSTRUCTION

Proposed changes in language are indicated as follows: language enclosed in black brackets ◘ indicates proposed deletions, and italic indicates proposed insertion of new language.

1. ◘$249,929,000◘ *$270,000,000*

The amount appropriated in fiscal year 1959 is deleted and the amount of the fiscal year 1960 appropriation request is inserted.

UNOBLIGATED BALANCES

Mr. CANNON. You might also include, Mr. Chairman, a tabulation showing for each of the last 5 years your budget estimates of net free unobligated balances and actual net free balance at the end of the fiscal year. Include also the estimated and actual total of unobligated balances, if you will.

(The information to be supplied follows:)

Tabulations of unobligated balances plant acquisition and construction appropriation

Fiscal year	Net free		Total	
	Estimate	Actual	Estimate	Actual
1959 (June 30, 1959)	23.5	(1)	152.2	(1)
1958 (June 30, 1958)	65.2	70.1	176.4	222.9
1957 (June 30, 1957)	103.2	99.5	296.6	308.0
1956 (June 30, 1956)	121.2	179.5	148.3	375.8
1955 (June 30, 1955)	582.4	[2] 701.5	582.4	755.3

[1] Not available.
[2] $571.4 million transferred to operating expenses.

FUNDING OF 1959 AND 1960 AUTHORIZED PROJECTS

Mr. CANNON. Are all projects authorized in the recent authorization bill being funded in full or in part in this legislative request?

Mr. MCCONE. All are being funded in full or in part. Furthermore, all authorized projects from 1959 which were not funded have been funded in full. You will recall last year there were some $30 million of items, only half of which were funded. We are funding all of the balance.

NUCLEAR SUPERHEAT REACTOR

There are two items I would like to bring to your attention. One was discussed earlier, the $11 million for the nuclear superheat reactor, which we are providing to carry forth the research and development and engineering work but not funding the construction for the reasons I mentioned this morning.

ENGINEERING WORK ON REACTOR AT ARGONNE

There is one other item of $1 million for initial engineering work on a reactor at the Argonne. This we can carry forward the conceptual engineering under our operating funds and we are not asking that that be funded. Otherwise everything is taken care of.

RAW MATERIALS

Mr. CANNON. Under the "Raw materials program" you are asking $100,000. We shall insert page 285.

(The page follows:)

RAW MATERIALS PROGRAM—CONSTRUCTION OBLIGATIONS

Program statement

Estimated obligations fiscal year 1960	$100,000
A. Obligations for new projects	(100,000)
B. Obligations for prior year projects	(0)
Estimated obligations fiscal year 1959	216,756
Actual obligations fiscal year 1958	745,381

Obligations for the raw materials program for fiscal year 1960 are estimated at $100,000, which amount is for a new project justified in section A below and authorized in the fiscal year 1960 authorization act:

SECTION A

The project in section A is:

Project No. 60-1. General plant projects:	
Total estimated cost	$100,000
Funded through fiscal year 1959	0
Estimated obligations fiscal year 1960	100,000
Funding required after fiscal year 1960 to complete project	0

EXPLANATION OF PROJECTS IN SECTION A

1 Project 60-1 General plant projects, $100,000.—This project is for minor capital improvements, alterations, additions, engineering, retirements and minor new construction which are required to maintain the Commission-owned raw materials facilities in an efficient and safe operating condition.

Special Nuclear Material

Mr. Cannon. Under special nuclear material you are requesting $149,880,000. We shall insert pages 286 through 291.

(The pages follow:)

Special Nuclear Materials Program—Construction Obligations

Program statement

Estimated obligations, fiscal year 1960	$149, 880, 000
A. Obligations for new projects	(115, 960, 000)
B. Obligations for prior year projects	(33, 920, 000)
Estimated obligations, fiscal year 1959	81, 689, 093
Actual obligations, fiscal year 1958	35, 090, 845

Obligations for the special nuclear materials program for fiscal year 1960 are estimated at $149,880,000, of which $115,960,000 is for the projects justified in section A below, which were authorized in the fiscal year 1960 authorization act, or were previously authorized and for which a request for appropriation was deferred until fiscal year 1960.

The balance of $33,920,000 is for projects listed under section B below, which were authorized prior to fiscal year 1960 and for which funds have previously been appropriated, but are now carried over into fiscal year 1960.

SECTION A

The projects comprising section A are as follows:

Project No.	Title	Total estimated cost	Funded through fiscal year 1959	Estimated obligations, fiscal year 1960	Funding required after fiscal year 1960 to complete project
60-a-1	Modifications to production and supporting installations	$10, 000, 000	0	$10, 000, 000	0
60-a-2	Prototype installations, gaseous diffusion plants	1, 000, 000	0	1, 000, 000	0
60-a-3	Central Computing Bldg., Oak Ridge, Tenn	1, 650, 000	0	1, 650, 000	0
60-a-4	Reactor air filters, Savannah River, S.C	5, 000, 000	0	5, 000, 000	0
60-a-5	Additional raw water line, Paducah, Ky	810, 000	0	810, 000	0
60-a-6	Waterplant expansion, 100 K area, Hanford, Wash	5, 000, 000	0	5, 000, 000	0
60-a-7	Modifications to reactor disassembly basins, Savannah River, S.C	1, 600, 000	0	1, 600, 000	0
60-b-1	Cylinder storage area, Paducah, Ky	500, 000	0	500, 000	0
60-b-2	Increased cooling water capacity, Savannah River, S.C	5, 000, 000	0	5, 000, 000	0
60(1)	General plant projects	10, 400, 000	0	10, 400, 000	0
59-a-5	Production reactor facility for special nuclear materials, convertible type, Hanford, Wash	145, 000, 000	$45, 000, 000	75, 000, 000	$25, 000, 000
	Total	185, 960, 000	45, 000, 000	115, 960, 000	25, 000, 000

Explanation of projects in section A

1. *Projects 60–a–1, modifications to production and supporting installations, $10,000,000.*—This project provides for the design, procurement, fabrication, and installation of equipment, together with the necessary plant modifications to existing facilities and/or construction of new facilities necessary to guarantee the continuity of operation, incorporation of technological advances, increases in productivity, increased safety of operations and assure the most economical operation of the production and supporting facilities under the administration of the Hanford, Savannah River, and Oak Ridge Operations Offices.

As in the case of the general plant projects, many of the items to be performed under this project cannot be identified specifically in advance, their need being predicated on the progress of process development work and changes in

program requirements. Examples of work which may be done under this project are: area criticality monitors, recovery of HF from slag, improved instrumentation, modifications, and changes to classified production facilities, additions to critical mass facilities to permit more efficient utilization of manpower and equipment, effluent system modifications at Hanford, high-speed scanning instrumentation, revisions to horizontal control rods, fission product recovery facilities, and other items as the need arises.

2. *Project 60–a–2, prototype installations, gaseous diffusion plants, $1,000,000.*—This project provides for prototype installations at one or more of the gaseous diffusion plants to recover a portion of the heat energy presently dissipated to cooling towers and convert this heat energy to electrical energy. Various methods of recovering this heat energy are under consideration and will be tested in the prototype installations. The prototype installations will test the compartive efficiency of the various alternatives. The diffusion plants use large quantities of electrical energy and dissipate large quantities of waste heat. The success of the prototype units will determine the extent of plant-wide installation of this type of conversion units.

3. *Project 60–a–3, central computing building, Oak Ridge, Tenn., $1,650,000.*—In order to maximize the operational and economic advantages of performing all computations on one computer setup, it is necessary to bring all groups whose functions require access to the computer into one building. The building proposed in this project replaces a building which was built 15 years ago as a temporary structure for construction use. Although the building has been kept in a fair state of repair, its cost of maintenance is excessive. Rather than add to this inadequate building, this project provides for construction of a new facility to properly house the electronic data processing machines as well as the personnel whose work is directly tied in with the operations of the computer and the financial and accounting systems.

4. *Project 60–a–4, reactor air filters, Savannah River, S.C., $5,000,000.*—This project provides for modifications and additions to the Savannah River reactors to prevent the release to the atmosphere of highly radioactive particulate matter in the event of an accident. It is proposed to accomplish this additional safety requirement by providing in each reactor a filter installation, together with blowers, dampers, and ductwork designed to divert the exhaust air through the filter prior to release through the existing stack. Although must attention was given to safety features in the original design of the Savannah River reactors, it is considered that this higher degree of protection should be provided against the possibility of an incident, such as the burning of an irradiated fuel element during discharge operations, which would release large quantities of particulate matter to the atmosphere.

5. *Project 60–a–5, additional raw-water line, Paducah, Ky., $810,000.*—This project provides for the construction of an additional raw-water line from the Ohio River to the gaseous diffusion plant area. The line will be approximately 4⅛ miles long.

The existing line was constructed in 1942 for use by the Kentucky Ordnance Works. This line has suffered from severe corrosion and pitting. Taking the line out of service is impracticable, in view of the nature of the gaseous diffusion operation. The new line proposed in this project is essential to guarantee continuity of operations.

6. *Project 60–a–6, water plant expansion, 100 K area, Hanford, Wash., $5,000,000.*—This project provides for increasing the process water flow to the K reactors. (Additional information of a classified nature is presented on p. 293.)

7. *Project 60–a–7, modifications to reactor disassembly basins, Savannah River, S.C., $1,600,000.*—This project provides for the installation of facilities for removing contamination and heat from the water in the reactor disassembly basins. The proposed facilities will permit the circulation of disassembly basin water through a heat exchanger into a primary filter to remove contaminated particulate matter and control turbidity. The cooled water would then be further decontaminated by means of ion exchange equipment and returned to the disassembly basins. Details of the project are dependent upon operating experience with a scaled-down version. Prior to the availability of this project, huge seepage basins will continue to be used in each reactor area for the removal of accumulated sludge from the disassembly basins and to discharge disassembly basin water when contaminated excessively by ruptured fuel elements. The use of seepage basins is limited by the effectiveness of the permeability of the soil and basins must be abandoned when they become effective.

8. *Project 60–b–1, cylinder storage area, Paducah, Ky., $500,000.*—This project provides for the construction and/or improvement of concrete storage pads supported by compacted gravel to withstand high-density loading. The project also provides for necessary grading, drainage, access roads, and perimeter fencing.

The residue remaining from the U^{235} isotopic separation consists of gaseous uranium hexafluoride. This material is stored in cylinders pending determination of further utilization of the material. The cylinders are then stored outside on concrete pads.

9. *Project 60–b–2, increased cooling water capacity, Savannah River, S.C., $5,000,000.*—This project is designed to obtain the most economical increase in the availability of cooling water used for reactor operations at the Savannah River plant. (Additional information of a classified nature is presented on p. 293.)

10. Project 60 (1), general plant projects, $10,400,000.—This project provides for the accomplishment of numerous miscellaneous changes and additions to production processing and supporting facilities of the Oak Ridge, Hanford, and Savannah River Operations Offices. Work of this kind is required on a continuing basis to adapt the facilities to new production requirements and process improvements, to assure continuity of operations, to reduce maintenance and operating costs and to reduce or eliminate health or security hazards.

The cost estimate for fiscal year 1960 is based on experience in prior years. Obligations in fiscal year 1959 will be approximately $9,240,000 for general plant construction. The estimate for this work in fiscal year 1960 is less than 1 percent of the capital value of all special nuclear materials plants under the jurisdiction of the Oak Ridge, Hanford, and Savannah River Operations Offices.

The amount requested for each operations office is as follows:

Operations Office:	*Amount*
Oak Ridge	$7,200,000
Hanford	2,000,000
Savannah River	1,200,000
Total	10,400,000

11. Project 59–a–5, production reactor facility for special nuclear materials, convertible type, Hanford, $75,000,000.—The additional funds requested for this project are to provide for continuation of construction of a graphite-moderated, water-cooled, plutonium production reactor, designed for future conversion to power production. This project was authorized in fiscal year 1959 for $145 million and $45 million was appropriated to initiate construction.

SECTION B

The projects comprising section B which have been previously authorized and for which funds have been appropriated previously, but are now carried over into fiscal year 1960, are:

Project No.	Title	Total estimated cost	Funded through fiscal year 1959	Obligations to be incurred in fiscal year 1960	Funding required after fiscal year 1960 to complete project
59-a-1	Plant modifications for processing of nonproduction spent fuels, undetermined sites	$15,000,000	$1,500,000	$8,500,000	$5,000,000
59-a-4	A new waste storage installation, Arco, Idaho	3,200,000	200,000	3,000,000	0
58-b-4	Improvements to production and supporting installations, Hanford, Wash., and Savannah River, S.C.	12,500,000	10,000,000	2,500,000	0
58-b-6	Additions to gaseous diffusion plants, Oak Ridge, Tenn	1,100,000	100,000	1,000,000	0
58-b-2	Mechanical production line, Hanford, Wash	1,870,000	1,500,000	370,000	0
57-a 2	Improvements to reactor instrumentation, Hanford, Wash. (excludes $15,000 AE under advance AE 1957 projects)	2,852,000	1,252,000	1,600,000	0
57-a-5	Additional waste disposal system, Hanford, Wash. (excludes $10,000 AE under advance AE 1957 projects)	3,776,000	2,776,000	1,000,000	0
57-a-6	Charging and discharging system, Hanford, Wash	3,450,000	0	3,450,000	0
56-d-2	Reactor facilities modifications, Hanford, Wash	13,800,000	12,300,000	1,500,000	0
4022	Pile modification facilities for increased production (phase I)	27,619,000	27,219,000	400,000	0
1016	Production reactor facilities, Savannah River	572,879,665	571,379,665	1,500,000	0
1017	Reactor products separations facilities, Savannah River	283,788,821	277,388,821	6,400,000	0
1018	Feed materials production and testing facilities, Savannah River	38,559,739	36,359,739	2,200,000	0
1019	Administrative, process development, and general services facilities	62,842,404	62,342,404	500,000	0
	Total	1,043,237,629	1,004,317,629	33,920,000	5,000,000

DUAL-PURPOSE REACTOR

Mr. CANNON. Last year funds were provided for a dual-purpose reactor at Hanford. What is the status of that project at this time?

Mr. MCCONE. Mr. Bloch can answer that.

Mr. BLOCH. That project is underway. Engineering is about 10 percent complete. The construction contractor is on the site. Procurement of the major critical equipment items has started.

This request includes $75 million to cover the funding required in fiscal 1960 to carry on this project.

Mr. CANNON. When will it go into production?

Mr. BLOCH. Our estimate is we will complete it in just about 3 years, about the summer or fall of 1962.

WEAPONS

Mr. CANNON. Under the weapons program you are requesting $38,141,000. We shall insert pages 294 through 299.

(The pages follow:)

WEAPONS PROGRAM—CONSTRUCTION OBLIGATIONS

Program statement

Estimated obligations, fiscal year 1960	$34,141,000
A—Obligations for new projects	(21,633,000)
B—Obligations for prior year projects	(12,508,000)
Estimated obligations, fiscal year 1959	48,130,230
Actual obligations, fiscal year 1958	48,374,322

Obligations for the weapons program for fiscal year 1960 are estimated at $34,141,000, of which $21,633,000 is for the projects justified in section A below which were authorized in the fiscal year 1960 authorization act. The balance of $12,508,000 is for projects listed under section B below which were authorized prior to fiscal year 1960 and for which funds have previously been appropriated and are carried over into fiscal year 1960.

SECTION A

The projects comprising section A are as follows:

Project No.	Title	Total estimated cost	Funded through fiscal year 1959	Estimated obligations, fiscal year 1960	Funding required after fiscal year 1960 to complete project
60-c-1	Weapons production, development, and test installations	$10,000,000	0	$10,000,000	0
60-c-2	Special processing plant, phase II, Mound Laboratory, Ohio	3,800,000	0	1,000,000	$2,800,000
60-c-3	Test and environmental installations, Sandia Base, N. Mex	1,000,000	0	1,000,000	0
60-d-1	Storage site modifications	1,500,000	0	1,500,000	0
60-d-2	Materials storage vault, Los Alamos, N. Mex	133,000	0	133,000	0
60-1	General plant projects	8,000,000	0	8,000,000	0
	Total	24,433,000	0	21,633,000	2,800,000

Explanation of projects in section A

1. *60-c-1 Weapons production, development, and test installations, $10 million.*—This project provides for the construction and acquisition of production, development, and test facilities which may be required to meet the future needs of the weapons program. Until the parameters of new weapons can be

accurately defined it is not possible to foresee all of the development, production, and testing operations that may be involved and whether existing facilities are adequate to accomplish the programs.

Experience indicates that numerous and rapid scientific and technological advances will give rise to a need for additional facilities which cannot be fully foreseen at the time of the regular budget submission. Research may lead to the introduction of new materials and alloys which require major change in manufacturing process and an associated addition to capital plant. New environmental conditions to which weapons will be subjected in supersonic carriers may require additional facilities where weapons and weapons components can be tested in simulated environments to insure reliability.

Similar projects in prior fiscal years have made it possible to proceed with the timely acquisition of facilities to exploit research and development findings and to expand production plants. This project will assure availability of funds to meet changes in production requirements and to provide research, development, and test facilities in order to enable the AEC to take early advantage of advances or changes in the weapons field.

2. *60–c–2 Special processing plant, phase II, Mound Laboratory, Ohio, $1 million.*—This project is phase II of the $2 million project being initiated during fiscal year 1959 to install a special processing capability at Mound Laboratory. The fiscal year 1960 project consists of two parts for which authorization was requested in the amount of $3,800,000. Preliminary design of the entire $3,800,000 project will proceed in fiscal year 1960; however, construction will be limited to a $1 million addition to the fiscal year 1959 project. Construction of the remaining $2,800,000 part of the project is deferred until after fiscal year 1960.

(Additional information of a classified nature is presented on page 300.)

3. *60–c–3 Test and environmental installations, Sandia Base, N. Mex., $1 million.*—This project is to provide special environmental facilities required for weapons development. The project includes an acoustic test installation and a dynamic test installation.

The acoustic test installation, estimated at $300,000, together with the increment authorized in fiscal year 1959, will provide a means of proving whether design configurations and components are compatible with severe noise fields. The facility will house environmental equipment such as an air supply system, air chopper, and transformer.

The dynamic shock installation, estimated at $700,000, is to provide a test facility capable of applying high accelerations to weapons or large components and will include test and other equipment such as a crane, air compressor, instrumentation and a small remote control building. With this facility it will be possible to prove out designs sufficiently to reduce the number of actual drop tests now required. This data will also provide greater degree of assurance during development.

Construction of these facilities is scheduled to begin in the second quarter of fiscal year 1960 and be completed in the second quarter of fiscal year 1961.

4. *60–d–1 Storage site modifications, $1,500,000.*—This project is to provide capital improvements, modifications, and additions to weapons storage site facilities. Requirements for modifications and additions arise from: (*a*) experience gained through use of facilities which reveal need for changes to improve operating conditions and efficiency; (*b*) changes in weapons characteristics, and (*c*) deterioartion to the extent that normal maintenance is no longer adequate and replacements are necessary.

Illustrative of the types of things for which the funds under this project are to be utilized are:

Road improvements
Replacement of igloo entrance pads
Improvements to surface drainage
Replacement of igloo floors
Access slabs on roads at railheads
Additions and modifications to storage structrues

Construction of these facilities is scheduled to begin in the second quarter of fiscal year 1960 and to be completed in the fourth quarter of fiscal year 1961.

5. *60–d–2 Materials storage vault, Los Alamos, N. Mex., $133,000.*—This project provides an addition to the existing source and special nuclear (SSN) materials storage vault. The present vault lacks sufficient capacity to handle the current workload of materials; consequently expensive packaging methods must be used so that material overflow can be stored in temporary areas. Many

of these materials are extremely radioactive and create a cross-contamination problem under present arrangements. In addition to providing additional storage capacity, this project will permit a reduction in cost of physical security and consolidation of SSN material storage thereby eliminating wasteful double handling.

Construction of this facility is scheduled to begin in the first quarter of fiscal year 1960 and be completed in the fourth quarter of fiscal year 1960.

6. *60–1 General plant projects, $8 million.*—This project consists of miscellaneous improvements, alterations, additions, replacements and minor new construction of facilities required in the operation of production, research, and development and other facilities of the weapons program. A project of this nature is a necessary and continuing requirement if safe and economical operating conditions are to be maintained and new program developments accommodated. The increasing size of the weapons capital plant, the aging of many facilities, and rapid technological developments underscore the need for adequate general plant funds in the budget year.

Estimate by operations office is as follows:

Albuquerque Operations Office	$5,500,000
San Francisco Operations Office	2,500,000
Total	8,000,000

SECTION B

The projects comprising section B which have been previously authorized and for which funds have previously been appropriated but are carried over into fiscal year 1960 are:

Project No.	Title	Total estimated cost	Funded through fiscal year 1959	Obligations to be incurred in fiscal year 1960	Funding required after fiscal year 1960 to complete project
59–b–1	Weapons production and development plants, location undetermined	$10,910,000	$7,752,000	$3,158,000	0
59–c–2	Base construction, EPG	2,342,000	500,000	1,842,000	0
59–c–3	Base construction, NTS	1,780,000	500,000	1,280,000	0
59–c–5	Phermex installation, Los Alamos, N. Mex	3,550,000	720,000	2,830,000	0
59–c–7	Test and environmental installation, Sandia Base, N. Mex	1,488,000	1,015,000	473,000	0
59–c–8	Lineal acceleration tester, Livermore, Calif	390,000	0	390,000	0
59–c–9	Test assembly building	510,000	0	510,000	0
58–d–9	Base construction, EPG	7,917,000	5,892,000	2,025,000	0
	Total	28,887,000	16,379,000	12,508,000	0

WEAPONS PRODUCTION, DEVELOPMENT, AND TEST INSTALLATIONS

Mr. CANNON. Why do you need this $10 million for test installation in view of the current prohibition against testing? We have agreed with the world we will not test for the present at least and still you are requesting $10 million for testing.

General STARBIRD. The project is actually these two lines, "Weapons production, development, and test installation." In other words, these are all of the essential features that we expect will come up during the coming fiscal year, but which cannot be picked out at the present moment as being necessary.

One of the things that makes our future in this regard rather indefinite is the test situation. We have quite a long list of items that we would like to build. Many of these are essential. However, the degree of essentiality will determine which we can build from this amount of $10 million.

Mr. CANNON. They are in anticipation of conditions and developments which may never occur, at least which we hope will never occur. You are putting them here as a matter of precaution. Is this a spare tire?

General STARBIRD. No, sir; this is not a spare tire. This is a group of installations and a group of facilities which we are sure will be necessary, but we cannot pick out at the present moment exactly which ones will be the critical ones to carry out during this fiscal year.

Mr. CANNON. How much of this is intended for Nevada and how much for Eniwetok?

General STARBIRD. None of it is intended for Eniwetok or Nevada, sir. On the other hand, should we go back to testing at, say, Nevada, then we would probably stop some of our essential production work and call off a few of the installation constructions we would do under this so we could do testing in Nevada.

To answer your question specifically, under the current expectation in the framework in which this budget was cast, none is for Nevada or Eniwetok.

REACTOR DEVELOPMENT

Mr. CANNON. Under "Reactor development" you are asking $161,914,000. We shall insert pages 301 through 315.

(The pages follow:)

REACTOR DEVELOPMENT PROGRAM—CONSTRUCTION OBLIGATIONS

Program statement

Estimated obligations, fiscal year 1960	$161, 914, 000
A—Obligations for new projects	(93, 650, 000)
B—Obligations for prior year projects	(68, 264, 000)
Estimated obligations, fiscal year 1959	162, 977, 286
Actual obligations, fiscal year 1958	100, 866, 621

Obligations for the reactor development program for fiscal year 1960 are estimated at $161,914,000 of which $93,650,000 is for new projects justified in section A below which were either authorized in the fiscal year 1959 authorization act, or were previously authorized and for which a request for appropriation was deferred until fiscal year 1960. The balance of $68,264,000 is for projects listed under section B below which were authorized prior to fiscal year 1960 and for which funds have previously been appropriated but are now carried over into fiscal year 1960.

SECTION A

The projects comprising section A are as follows:

Project No.	Title	Total estimated cost	Funded through fiscal year 1959	Estimated obligations, fiscal year 1960	Funding required after fiscal year 1960 to complete project
60-e-1	Modification to experimental breeder reactor No. 1 (EBR-1), National Reactor Testing Station, Idaho	$1,000,000	0	$1,000,000	0
60-e-2	Portable gas-cooled reactor prototype, National Reactor Testing Station, Idaho	2,500,000	0	2,500,000	0
60-e-3	Alterations, modifications, and additions to MTR-ETR utility, technical, and support installations, National Reactor Testing Station, Idaho	2,000,000	0	2,000,000	0
60-e-4	Hot cells	2,500,000	0	2,500,000	0
60-e-5	Chemical processing plant area utility modifications and improvements, National Reactor Testing Station, Idaho	750,000	0	750,000	0
60-e-6	Reactor support installations, Nevada test site	500,000	0	500,000	0
60-e-7	Nuclear test plant, Army reactor experimental area (AREA), National Reactor Testing Station, Idaho	5,000,000	0	5,000,000	0
60-e-8	Modifications and additions for test installation for Project Pluto	2,000,000	0	2,000,000	0
60-e-9	Research and development test plant additions and modifications for Project Rover	4,800,000	0	4,800,000	0
60-e-10	General support installation and utilities expansion, Argonne National Laboratory, Illinois	4,300,000	0	4,300,000	0
60-e-11	Natural circulation test plant, National Reactor Testing Station, Idaho	18,500,000	0	6,000,000	$12,500,000
60-e-12	Alterations to Shippingport reactor facilities	5,000,000	0	5,000,000	0
60-e-13	Experimental organic-cooled reactor, National Reactor Testing Station, Idaho	6,000,000	0	6,000,000	0
60-e-14	Experimental low-temperature process heat reactor	4,000,000	0	4,000,000	0
60-f-1	Miscellaneous modifications and additions, Argonne National Laboratory, Illinois	1,000,000	0	1,000,000	0
60-1	General plant projects	7,500,000	0	7,500,000	0
60-110	Cooperative power reactor demonstration program	25,000,000	0	25,000,000	0
59-d-7	Modifications to organic moderated reactor experiment (OMRE), experimental boiling water reactor (EBWR), and boiling reactor experiment (BORAX)	5,300,000	$2,500,000	2,800,000	0
58-e-16	Destroyer reactor plant, West Milton, N.Y.	35,000,000	24,000,000	11,000,000	0
	Total	132,650,000	26,500,000	93,650,000	12,500,000

Explanation of projects in section A

1. *Project 60-e-1 Modification to experimental breeder reactor No. 1 (EBR-1) National Reactor Testing Station, Idaho, $1 million.—This project provides* for the design, construction, and addition of modification and improvements to the experimental breeder reactor No. 1, located at the National Reactor Testing Station, as may be necessary for the incorporation of a plutonium-bearing core and continued experimental investigations into the reactor system. The nature of the precise modifications to be made will depend largely upon the specific core and the type of investigations to be conducted.

While no major structural changes are contemplated within this project, the following is the type of work presently planned for—

(1) Modifications for installation, handling and storage, of a plutonium bearing core.

(2) Modifications to the reactor controls, instrumentation and facility to—

(*a*) assure operational flexibility; and

(*b*) maintain adequate radiological safety standards.

(3) Other modifications required for continued experimental investigations of physical parameters, operating conditions, and kinetics of a plutonium bearing core.

2. *Project 60–e–2 Portable gas-cooled reactor prototype, National Reactor Testing Station, Idaho, $2,500,000.*—This project provides for the design, engineering, and construction of the nuclear portions of a prototype portable nuclear powerplant to be located at the National Reactor Testing Station. As currently visualized the reactor will be gas cooled and water moderated and will have an electrical capacity of several hundred kilowatts. Included will be such items as the reactor, shutdown shielding, instrumentation, closed cycle gas turbine power conversion equipment, and a remote operating console.

AEC funds will be used for the design and construction of the reactor plant, while the Department of Defense will fund the design and construction of the conventional power conversion equipment at an estimated cost of $2,200,000.

The principal purpose of this project is to obtain a reactor plant capable of air and rail transport which will also have the capacity to operate reliably under extreme conditions of environment without dependence on a supply of continuous cooling water.

3. *Project 60–e–3 Alterations, modifications and additions to MTR-ETR utility, technical and support installations, National Reactor Testing Station, Idaho, $2,000,000.*—This project provides for the design, engineering, and construction of alterations, modifications, and additions to MTR–ETR utilities, area service system, and operating and development facilities to permit increased utilization of the potentialities of the MTR and ETR as test tools. This work is required because existing usable space in the MTR–ETR area is being employed beyond the point of safe, efficient, and economical utilization due to the construction of additional facilities and the demands of experimenter utilities.

The work to be undertaken by this project as currently planned may include such items as—expansion of water distribution, provision of a new substation, additions to the permanent utilities at the ETR, construction of additional laboratory space, and the installation of utility services to provide for expanded experimental requirements in the ETR.

4. *Project 60–e–4 Hot cells, $2,500,000.*—This project provides for the design, engineering, and construction of hot cell facilities at various AEC laboratory locations in existing buildings, extensions to buildings, or new buildings. The hot cells are requred to do such things as—

(1) Perform research and study work on the effect of reactor radiation on reactor fuels and construction materials.

(2) Examine, service, and dismantle inpile loops and experiments contained therein.

(3) Cast, roll, and fabricate radioactive materials and alloys for preparation of samples for further irradiations.

(4) Study remote metallurgical, pyrometallurgical, and chemical processing of radioactive fuels and materials.

While the precise construction designs are dependent upon the nature of work to be performed in the cells, it is planned that these cells will be of stainless steel-lined, high-density concrete construction. Also provided for under this project are the related ventilation systems, equipment, viewing windows, and manipulators.

5. *60–e–5 Chemical processing plant area utility modifications and improvements, National Reactor Testing Station, Idaho, $750,000.*—This project provides for the design, engineering, procurement, and consrtuction of various additions and extensions to the service systems at the Idaho chemical processing plant. This work is required to insure continuous plant operation, supplement existing services now being used to the maximum extent, and provide additional services for new facilities to be operated in the CPP area, such as the hot pilot plant, waste calcination facility, and process improvement facility.

The type of work contemplated under this project includes such things as—

(1) steam distribution system;

(2) sanitary sewer distribution system;

(3) expansion of plant air system;

(4) liquid waste system;

(5) general storm drainage work;

(6) water system.

6. *Project 60–e–6 Reactor support installations, Nevada test site, $500,000.*—This project provides for the design, construction, and modification of common technical service and support facilities required by reactor program field testing activities at the Nevada test site (NTS). These facilities are required in support of the Rover, Pluto, and fast reactor programs.

The work planned under this project at the current time may provide for such items as consolidated communication facilities; rad-safe building, fire stations, and equipment.

7. *Project 60–e–7 Nuclear test plant, Army reactor experimental area (AREA), National Reactor Testing Station, Idaho, $500,000,000.*—This project provides for design, engineering and construction of a pressurized water nuclear test reactor for full-scale core testing of Army nuclear power program APPR-type pressurized water reactor cores before their use in ANPP reactors.

Alternative test methods would be inadequate to evaluate properly and to test a maximum reliability operational core. To guarantee operational reliability of the reactor portion of a new nuclear powerplant, the full-scale nuclear core should be tested in a prototype reactor or in a test facility as proposed. This facility is intended to meet core-testing requirements for pressurized water reactors in the Army nuclear power program and is designed to obviate the construction of a prototype reactor for each such project.

The reactor provided for by this project will be highly instrumented and adjustable to facilitate testing different cores under operating field conditions for which the cores are designed.

8. *Project 60–e–8 Modifications and additions for test installation for Project Pluto, $2,000,000.*—This project provides for design, engineering, and construction of modifications and additions to Pluto testing facilities at the E. O. Lawrence Radiation Laboratory (LRL) at Livermore and the Nevada test site (NTS). This work is required for the testing of advanced-type reactors and includes such things as—

(1) structural modifications to accommodate new equipment;
(2) procurement of new equipment; and
(3) modifications to the initial Pluto test facilities for advanced tests.

9. *Project 60–e–9 Research and development test plant additions and modifications for Project Rover, $4,800,000.*—This project provides for the design, engineering, construction, and modification of laboratory research and development facilities at Los Alamos and additions and modifications to reactor field testing facilities at the Nevada test site (NTS). The proposed work is essential to the Los Alamos Scientific Laboratory nuclear propulsion program. (Project Rover) and to the field testing of the various reactors which have been provided for in previous budgets. The work to be undertaken will provide both testing and fabrication facilities to meet the program requirements for these functions.

10. *60–e–10 General support installations and utilities expansion, Argonne National Laboratory, Illinois, $4,300,000.*—This project provides for the design, engineering, and construction of improvements, such as alterations, modifications, and additions to the utility and waste system facilities at the Argonne National Laboratory. These improvements are required to both meet the demands of new construction, underway or authorized, and existing research facilities, as well as to insure their continuous operation.

The work planned under this project will be performed on some or all of the following utilities:

(1) Steamplant.
(2) Waste treatment plant.
(3) Waste collection system.
(4) Canal cooling water system.
(5) Electrical distribution system.
(6) Waste processing, storage, and shipping facilities.

11. *Project 60–e–11 Natural circulation test plant, National Reactor Testing Station, Idaho, $6,000,000.*—This project provides for the construction of a facility for the full-scale operation and testing of a natural circulation reactor plant for naval ship propulsion. The Department of Defense established a requirement for a natural circulation reactor in its letter of September 3, 1958, which requested the Atomic Energy Commission to undertake the early development and test of such a plant. The reactor plant will consist of a reactor, a primary coolant system, and essential controls and instruments. This type of plant utilizes a thermal head to circulate the reactor coolant, thus eliminating the need for coolant pumps and associated electrical generating and control equipment.

A natural circulation reactor plant offers promise of a significant advance in the field of pressurized water reactors for naval ship propulsion because of (1) inherent safety expected in the testing and operation of the reactor plant, (2) plant simplification, and (3) increased reliability. The design of the reactor for a natural circulation plant differs considerably from the forced circulation pressurized water reactor design. As a result, developmental problems are introduced which require the construction of a full-scale test plant. To date the development of this type of a reactor plant has been confined to analytical studies and small-scale out-of-pile experimental tests.

Of the total estimated cost of $18,500,000 for this project, $6 million of obligational authority will be required in fiscal year 1960. Commitments against these funds will include engineering and design of site facilities, design and procurement of reactor plant components, and initial physical construction.

12. *Project 60–e–12 Alterations to Shippingport reactor facilities, $5,000,000.*—This project provides for modification to the reactor plant of the Shippingport Atomic Power Station, at Shippingport, Pa., in order to permit operation at a power level sufficient to generate 150 megawatts' gross electrical output. Modifications will consist of required changes in certain components and systems of the reactor plant, primarily pressurizer and pressure relief system, steam generators, and instrumentation and control systems.

The Shippingport plant was constructed to obtain information relative to the design, operation, and maintenance of central station nuclear powerplants, with the primary objective of advancing general power reactor technology. The development of longer life, high-power density cores is a major goal in this effort. The design of core No. 2 has now reached the point where it appears that this core will have sufficient capacity for generation of approximately 150 megawatts' gross electrical output. In order to take advantage of the higher anticipated performance of core 2 and to demonstrate the maximum power capability that can be obtained from a primary system of the size and design of the reactor installed in the Shippingport plant, it is necessary to make these reactor plant modifications.

13. *Project 60–e–13 Experimental organic-cooled reactor, National Reactor Testing Station, Idaho, $6,000,000.*—This project provides for the design and construction of an experimental test reactor to further the development of organic-cooled concept reactors. The power level of the reactor will be in the neighborhood of 20–40 thermal megawatts; generation of electricity is not contemplated. The reactor is planned to be located at the National Reactor Testing Station, Idaho.

The experimental organic-cooled reactor will provide reactor space for irradiation of prototype fuel elements in statistical quantities and should produce information on organic coolants at an accelerated rate. It is intended that this project serve as a major tool for advancing organic reactor technology in the period from 1961 to 1965.

14. *Project 60–e–14 Experimental low-temperature process heat reactor, $4,000,000.*—This project provides for the design and construction of an experimental low-temperature process heat reactor to demonstrate the technical and economic feasibility of reliably producing low-temperature and hence low-pressure steam for utilization in process industries. This project will facilitate experimental and operational research and development leading to larger and less costly future plants which offer promise of being a reliable and competitive heat source.

The Commission is authorized to enter into a cooperative arrangement with any party for participation in the development, construction, and operation of the project, and the utilization of the steam generated by the reactor plant to the fullest extent consistent with the Commission's direction of the project and ownership of the reactor as provided for in the fiscal year 1960 Authorization Act for the Atomic Energy Commission.

15. *Project 60–f–1 Miscellaneous modifications and additions, Argonne National Laboratory, Illinois, $1,000,000.*—This project provides for modifications and additions and such other changes as may be necessary to move the International Institute of Nuclear Science and Engineering out of the Physics Building and the Experimental Waste Processing Building. Also provided for is modification and extension of existing space and additional laboratory facilities to keep potentially dangerous amounts of radioactive material out of the areas subject to heavy traffic by nontechnical inexperienced personnel.

Completion of the fuels technology center and the chemistry hot laboratory will make space available for the Institute which, with modifications and re-

habilitation provided for under this project, should prove adequate for anticipated Institute courses.

16. *Project 60–1 General plant projects, $7,500,000.*—The work contemplated under this project consists of many miscellaneous improvements, alterations, and additions, including minor new construction. Similar work is performed annually in order to provide for continuity of operations, improvements in techniques, and reduction in operating costs in the various facilities of the reactor development program. Obligations in fiscal year 1959 will be approximately $6,109,000.

Since many of the items contained herein are recurring in nature, funds for these types of work are requested on past years' experience. The estimate is for the requirements of the following operations offices:

Chicago Operations Office	$2,500,000
Idaho Operations Office	2,000,000
New York Operations Office	1,000,000
Pittsburgh Naval Reactors Operations Office	1,200,000
Schenectady Naval Reactors Operations Office	800,000
Total	7,500,000

17. *Project 60–110 Cooperative power reactor demonstration program, $25,000,000.*—This project provides for the reinstituting and supplementing of the second round of the cooperative power reactor demonstration program. Funds are required for the development, design, construction, and operation of two reactor prototypes in accordance with subsection 111(a)(1) of Public Law 85–162, which shall be based on established reactor technology.

Contemplated under this project by the Commission are a small power prototype reactor and an intermediate power prototype reactor; however, the Commission is not limited to these types.

In the event that no satisfactory proposals are received, the Commission may, if the project is still deemed desirable, proceed with this project without either private or public organization assistance under a cooperative arrangement.

It is estimated that the small protoype reactor may cost $10 million and the intermediate size $15 million.

18. *Project 59–d–7 Modifications to organic moderated reactor experiment (OMRE), experimental boiling water reactor (EBWR), and boiling reactor experiment (Borax), $2,800,000.*—This project provides for design, engineering and construction of modifications, alterations, and additions, to the OMRE, EBWR, and Borax, for the following purposes:

OMRE (NRTS): To facilitate reactor operations and correct present difficulties in the reactor system by the contemplated expansion of the control room, laboratory, office space, and change room; installation of a new electrical substation; installation of a new reactor vessel; and improved facilities for fuel handling.

EBWR (ANL): To determine the maximum capabilities and stability limits of the plant with the present metallic core and with subsequent oxide and metallic cores; and, subsequently analysis and comparison of the plant's performance with D_2O and H_2O using both forced and natural circulation of the coolant moderator. The work presently planned provides additional heat removal capacity for increasing the EBWR rating to 100 MWT and later changes for operation with forced circulation and D_2O.

Borax (NRTS): To accommodate nuclear superheat fuel and subsequently nuclear superheat cores, and to increase the power level to 40 MWT. Subsequent tests will evaluate forced circulation, effects of various riser heights, use of orificing or adjustable restrictions in fuel element passages and nuclear superheat feasibility tests. The work planned under this subproject is: a new pressure vessel, pit, shielding, forced circulation and associated equipment, and additions to existing structures.

The total estimated cost of this project has been revised from $6,300,000 to $5,300,000, a reduction of $1 million representing an anticipated savings. It is expected that the work to be undertaken under each subproject will cost the following amounts:

EBWR	$3,000,000
Borax	1,800,000
OMRE	500,000
Total	5,300,000

The $2,800,000 requested for appropriation in fiscal year 1960 is required to complete the funding of this project, and will be used to initiate work on the OMRE and continue work started in fiscal year 1959 on the EBWR and Borax. In fiscal year 1959, $1 million was made available for work on Borax V and $1,500,000 for work on EBWR.

19. *Project 58–e–16 Destroyer reactor facility, West Milton, N.Y., $11 million.*—This project consists of a land prototype (D1G) of a destroyer nuclear propulsion plant and related facilities required for support and test operations of the plant. This prototype will consist of a section of a destroyer hull containing a reactor compartment with one reactor and with steam generating equipment, including related controls and auxiliary systems. The destroyer itself will have two such reactor plants and two shafts. The project will be constructed at the AEC West Milton, N.Y., site; the hull will be installed in the sphere that was previously used for submarine intermediate reactor (S1G) prototype. Maximum use will be made of existing facilities at the site.

The Navy has included a nuclear powered destroyer in the fiscal year 1959 shipbuilding program in order to evaluate this ship at the earliest practicable time. In order to meet the Navy's requirement for this ship, the D1G prototype must be in operation in early fiscal year 1961. The Knolls Atomic Power Laboratory is designing the propulsion plant on an urgent basis. The reactor design will include advances in the area of nuclear physics, heat transfer, reactor control, fuel element design, and core life.

The total estimated cost of $35 million is based on installation of the facility at West Milton, N.Y. The principal contractor is the General Electric Co.

In fiscal year 1958, $3,879,000 was obligated for architect-engineer services and to order major long leadtime reactor plant components and materials for construction of the prototype. During fiscal year 1959 a total of $20,121,000 will be obligated. Design of the supporting site facilities was essentially completed and construction was started. The remaining major reactor plant components were ordered and physical construction of the prototype began. Obligational authority of $11 million, the balance of the authorized amount for this project, is required in fiscal year 1960 for scheduled completion of the prototype plant.

SECTION B

The projects comprising section B which have been previously authorized and for which funds have been previously appropriated but are now carried over into fiscal year 1960 are:

Project No.	Title	Total estimated cost	Funded through fiscal year 1959	Estimated obligations, fiscal year 1960	Funding required after fiscal year 1960 to complete project
59–d–1	Reprocessing pilot plant, ORNL, Tennessee	$3,500,000	$500,000	$3,000,000	0
59–d–5	Hot cells	5,000,000	1,813,000	3,187,000	0
59–d–9	Fuels technology center addition, ANL, Illinois	5,000,000	3,800,000	1,200,000	0
59–d–10	Flexible experimental prototype gas-cooled reactor	30,000,000	6,000,000	24,000,000	0
59–d–15	Metals and ceramics research building, ORNL, Tennessee	6,500,000	500,000	6,000,000	0
58–e–1	Power reactor acceleration project	10,106,000	7,306,000	2,800,000	0
58–e–4	Modification and additions, ANP ground test plant, area No. 1, NRTS, Idaho	8,000,000	2,400,000	4,100,000	$1,500,000
58–e–15	Plutonium recycle test reactor	14,000,000	12,000,000	2,000,000	0
58–111	Cooperative power reactor demonstration program	49,971,000	33,345,000	5,633,000	10,993,000
57–e–2	Research and development test plant	27,484,000	23,222,000	4,262,000	0
57–e–3	Modifications and expansion of ANP ground test facilities, area No. 1, Idaho	15,000,000	9,300,000	5,700,000	0
57–g–1	Addition to electrical power system, NRTS, Idaho	3,300,000	2,068,000	682,000	550,000
57–XXX	Nuclear powered merchant ship reactor	26,250,000	22,750,000	3,500,000	0
56–b–2	Fast power breeder pilot facility (EBR–II)	29,100,000	27,900,000	1,200,000	0
56–b–6	ANP program plant and test area, Arco, Idaho	13,000,000	9,000,000	1,000,000	3,000,000
	Total	246,211,000	161,904,000	68,264,000	16,043,000

STATUS OF GAS-COOLED POWER REACTOR

Mr. CANNON. Last year the Congress took action to get started a large-scale gas-cooled reactor. What is the status of that project?

Mr. MCCONE. That project has been redesigned as a large-scale gas-cooled test reactor and a power producer. It is to be built at Oak Ridge at a cost estimated to be $30 million. The plant will produce 25,000-kilowatt electrical. In addition, it will be equipped with the necessary facilities for testing fuel elements and other components. It is an essential part of our whole gas-cooled reactor program. The other part involves a contract with the Philadelphia Electric Co., and some 50 utilities for construction of a high temperature gas-cooled reactor at a cost to them of about $25 million, but no cost to us at all.

Concurrently the execution of a contract with the General Dynamics Co. for the necessary research and development work for this type of reactor, which will cost the Atomic Energy Commission $14.5 million, and this operating budget provides $2.5 million or $3 million as our expenditure under that contract for this year.

Mr. CANNON. Mr. Chairman, you are getting away from what the committee had in mind. I do not see how we could have been mistaken. I am certain we were not mistaken. We intended this to be a plant. You have twisted it around until it is now part of a research program. Our instructions last year were clear. We provided money specifically for the purpose of establishing a large-scale gas-cooled reactor to be a plant.

Mr. MCCONE. That is what we are going to do. This will be a 25,000-kilowatt reactor, which is just about the size of the one you provided last year.

Mr. CANNON. You just said you are instituting a research program here.

Mr. MCCONE. That is right; we want to use this in addition to producing power, which will be consumed——

Mr. CANNON. It will produce power commercially?

Mr. MCCONE. It will produce 25,000 kilowatts of power. We will consume that power at Oak Ridge. In addition to that, it will provide us with some test loops which we need.

POWER REACTOR DEMONSTRATION PROGRAM

Mr. CANNON. Right along that same idea, what opportunities will there be for REA and private utilities to participate in the power reactor program in 1960?

Mr. MCCONE. The authorization bill provides for two reactors under the second round, one a small reactor which will demonstrate the production of nuclear power in a simple and modest-sized plant, the other may be an intermediate size reactor. The size and type is not specified.

Mr. CANNON. Will you proceed. I misunderstood you.

Mr. MCCONE. This bill provides for reopening of the second round and authorization to build two reactors under it if suitable arrangements can be made.

Mr. CANNON. It was the second round I thought you had omitted, but you are going ahead with the second round?

Mr. MCCONE. That is right.

AIRCRAFT NUCLEAR PROPULSION

Mr. CANNON. What is this million-dollar program for the ANP project? How is that to be used?

Mr. MCCONE. General Keirn can answer that.

Dr. PITTMAN. I cannot identify the particular item you are speaking of.

Mr. MCCARTHY. It is the carryover item on page 315.

Mr. CANNON. You will recall it is the aircraft program.

Mr. KEIRN. This is a carryover of a million dollars for the concrete apron and lighting for the FET and $3 million for a program to design and develop filters to be used in the exhaust system of the flight engine test facility. The program at present is limited to one of design and experimentation to determine whether or not we can in fact produce a filter which will be adequate to use in the exhaust system to catch fission products that may be released from our reactor experiments.

Mr. CANNON. Do you anticipate some appreciable progress in the coming year?

Mr. KEIRN. I do not anticipate a great deal of progress, although it is quite important to us, if we can move on into some of the reactors which we are contemplating in the future. I think we must try to find ways of accomplishing this.

PHYSICAL RESEARCH

Mr. CANNON. Under the physical research program, you are requesting $64,899,000. We shall insert pages 316 through 328.

(The pages referred to follow:)

PHYSICAL RESEARCH PROGRAM, CONSTRUCTION OBLIGATIONS

Program statement

Estimated obligations fiscal year 1960	$64, 899, 000
A—Obligations for new projects	(51, 755, 000)
B—Obligations for prior year projects	(13, 144, 000)
Estimated obligations fiscal year 1959	43, 586, 197
Actual obligations fiscal year 1958	14, 772, 545

Obligations for the "Physical research program" for fiscal year 1960 are estimated at $64,899,000, of which $51,755,000 is for the projects justified in section A below which were authorized in the fiscal year 1960 authorization act or were previously authorized and for which a request for appropriation was deferred until fiscal year 1960. The balance of $13,144,000 is for projects listed under section B below which were authorized prior to fiscal year 1960 and for which funds have previously been appropriated but are now carried over into fiscal year 1960.

SECTION A

The projects comprising section A are as follows:

Project No.	Title	Total estimated cost	Funded through fiscal year 1959	Estimated obligations, fiscal year 1960	Funding required after fiscal year 1960 to complete project
60-g-1	Project Sherwood Plant	$1,000,000	0	$1,000,000	0
60-g-2	Accelerator and reactor modifications, Brookhaven National Laboratory, New York	1,950,000	0	1,950,000	0
60-g-3	Transuranium Laboratory, Oak Ridge National Laboratory, Tennessee	1,200,000	0	1,200,000	0
60-g-4	Physics Building, Lawrence Radiation Laboratory, California	2,000,000	0	2,000,000	0
60-g-5	10 Mev Tandem Van de Graaff accelerator, Oak Ridge, Tenn	2,400,000	0	2,400,000	0
60-1	General plant projects	2,500,000	0	2,500,000	0
59-e-1	Accelerator improvements, University of California Radiation Laboratory, California	1,325,000	$800,000	525,000	0
59-e-7	Chemistry Hot Laboratory, Argonne National Laboratory	4,415,000	0	4,415,000	0
59-e-11	High flux research reactor, Brookhaven National Laboratory (as amended by fiscal year 1960 authorization)	10,000,000	1,000,000	9,000,000	0
59-e-13	Van de Graaff accelerator, Argonne National Laboratory	2,500,000	0	2,500,000	0
59-e-15	Research reactor, Ames Laboratory	3,765,000	0	3,765,000	0
57-d-1	High energy accelerator (as amended by fiscal year 1958 authorization)	29,000,000	13,500,000	15,500,000	0
4019	Alternating gradient proton synchrotron, Brookhaven National Laboratory, New York	31,000,000	26,000,000	5,000,000	0
	Total	93,055,000	41,300,000	51,755,000	0

Explanation of projects in section A

1. *Project 60-g-1 project Sherwood plant, $1,000,000.*—Decisions concerning the assembly of rather sizable experimental models and their supporting installations in the controlled thermonuclear program are largely dependent upon successful operation of smaller models and the resolution of a number of technical and theoretical problems. Recent developments in the controlled thermonuclear program indicate that the progress in this field will continue and will probably warrant the initiation of one or more models of such size that additional facilities for the development program and the housing of research machines and related power equipment may be required. Continued progress may be delayed if construction funds are not available for use immediately when needed. To prevent any needless delays in this research program this project provides $1 million for the construction of supporting facilities whenever necessary at the several sites where controlled thermonuclear research is in progress.

2. *Project 60-g-2 accelerator and reactor modifications, Brookhaven National Laboratory, New York, $1,950,000.*—This project provides for additions, modifications and improvements to the Brookhaven National Laboratory's research machines (the graphite research reactor, the cosmotron, and the alternating gradient synchrotron). This is a recurring request similar to the University of California accelerator improvements projects. From fiscal year 1956 to fiscal year 1958 this type of construction work was a small fraction of the laboratory's entire gentral plant projects program and was therefore included as a part of general plant projects. With the scheduled start-up of the 30 Bev AGS accelerator in fiscal year 1960 and the initiation of its research program, the funds needed for accelerator modifications and additions exceed the routine requirement of the Laboratory. This has led to reestablishing this project item separately from the general plant projects budget request.

The improvements and modifications provided by this project will increase the utilization of the Laboratory's machines and the scope and type of experiments that can be conducted with each of the two accelerators and the reactor.

Projects presently planned and under consideration include—

1. Reactor:
   (*a*) Safety instrumentation modification and improvements.
   (*b*) Miscellaneous modifications to auxiliary facilities such as pneumatic tube system, handling equipment, air exhaust and filters at canal house, etc.
2. Cosmotron:
   (*a*) Ripple filter for main magnet.
   (*b*) Beam separation equipment.
   (*c*) Direct current power supplies (125- and 250-kilowatt motor generator sets).
3. Alternating gradient synchrotron:
   (*a*) Power supplies, direct current (motor generator sets with total capacity of 7,500 kilowatts).
   (*b*) Shielding for external beams and experiments.
   (*c*) Safety devices, vents, blowers, detection instruments, etc.

3. *Project 60–g–3 transuranium laboratory, Oak Ridge National Laboratory, Tennessee, $1,200,000.*—This project is for the construction of an addition to the existing isolation laboratory building at Oak Ridge National Laboratory. This laboratory is required to develop processes and to provide a facility for the separation of transuranium elements including americium, curium, berkelium, and californium. This laboratory will be capable of handling the separation and refabrication of reactor targets and gram quantities of americium and curium and milligram quantities of berkelium and californium.

Work with transuranium elements requires a facility capable of handling high level neutron, alpha, and gamma emitting elements in solution and solid form. The present isolation laboratory is equipped to handle the high alpha activity, but it is not adequate for the neutron and gamma radiation levels that will be involved.

The large-scale processing of irradiated plutonium is to be carried out in the ORNL thorex pilot plant for the recovery of the plutonium isotopes separated from transuranium isotopes and fission products. The transuranium elements are valuable products that may also be recovered by reprocessing the waste in the thorex pilot plant with subsequent final separation and purification in the proposed new laboratory.

4. *Project 60–g–4, physics building, Lawrence Radiation Laboratory, Calif., $2 million.*—This project provides for a building containing office space, light laboratory areas and special research facilities to accommodate approximately 250 scientific and technical personnel. These facilities will provide an extension of the physics research effort housed in the central research laboratory. It will also provide permanent housing for the computer facility and film processing units.

The requirement for the physics building results from three basic considerations (1) present overcrowded conditions in existing physics research areas, (2) additional space requirements to accommodate contemplated staff and program growth, and (3) the need for a data and film processing center adequate to handle both the current and future work volume.

The physics program is following a planned course of program development which includes the use of the bevatron building addition as an experimental area, a third shift usage of the bevatron, and operation usage of the 72-inch bubble chamber. The increased program activity associated with the use of these facilities will generate additional requirements for computed usage in the reduction of data. To provide space for physics research personnel, many temporary expedients have been taken. Despite numerous alterations to the building interior and the reassignment of space, the central research laboratory, which houses most of the direct physics staff excluding the accelerator operations, is taxed beyond capacity. As additions are made to the physics staff, this situation becomes more acute. The space problem in the central research laboratory building is accentuated as research tends to require greater quantities of massive, complex equipment. Completed in 1949, the central research laboratory building was designed and equipped to accommodate 190 people. The current complement in the building is nearly 300.

5. *Project 60–g–5 10-Mev tandem Van de Graaff accelerator, Oak Ridge, Tenn., $2,400,000.* This project provides for the procurement of a 10 Mev tandem Van de Graaff accelerator and the construction of a building addition to house the accelerator and associated experimental equipment. The proposed building would be an addition constructed adjacent to the high voltage laboratory.

The ORNL high voltage laboratory has made important contributions to the field of low energy nuclear physics. Studies of neutron interactions, of energy levels in light nuclei, of nuclear Q values, and of the structure of medium and heavy nuclei have furthered our understanding of the nucleus. Neutron cross sections have also proved to be of value in the design of nuclear reactors and shields. In the short time that it has existed, the high voltage laboratory has grown to be one of the leading centers for research of this nature.

The present emphasis in this field is toward pulsed beams (in the millimicrosecond region), higher beam intensities, improved energy resolution, heavier bombarding particles, and higher bombarding energies. Furthermore, as experiments become increasingly complex, the preparation and setup times are becoming a major effort of the experimenter. At present there are approximately 16 physicists in the high voltage laboratory working on nearly that many different types of experiments. A generous amount of accelerator time has also been allotted to experiments undertaken by people from other divisions. All these things have resulted in rather tight scheduling of the two existing Van de Graaff accelerators (3 Mev and 5.5 Mev). On the 5.5 Mev machine, for example, a given experimenter has use of the accelerator for 1 week about every 3 months.

6. Project 60–1 general plant projects, $6,500,000.—This project provides for the minor and often individually unpredictable capital improvements, modifications and additions that are required for the Oak Ridge National Laboratory, the Ames Laboratory, and the off-site physical research program. The modifications and improvements that are made possible by this request are important to continued progress in the Commission's research and development program.

The general plant project funds requested for fiscal year 1960 will be used as follows:

Oak Ridge National Laboratory	$1,500,000
Ames Laboratory	50,000
Off-site research program	950,000
Total	2,500,000

7. 59–e–1 Accelerator improvements, University of California Radiation Laboratory, California, $525,000.—This project provides for further improvements to existing accelerators at the University of California Radiation Laboratory, Berkeley, Calif. (recently renamed the E. O. Lawrence Radiation Laboratory). The expanded physical research program at Berkeley contemplates an increase in the variety and number of experiments utilizing the accelerators.

This project was authorized in fiscal year 1959, and the total estimated cost is $1,325,000. The amount of $800,000 was appropriated therefor in fiscal year 1959. The balance of $525,000 requested in fiscal year 1960 includes funds for the conversion of the 340 million electron volts electron synchrotron to a 500 million electron volts machine, and for continuation of work started on the external extraction of the full energy beam from the bevatron.

Extraction of the complete bevatron beam will open up a whole panorama of experimental effort and will provide additional flexibility and versatility of bevatron utilization. The external beam will allow full usage of additional target stations and simultaneous experimentation with positive and negative meson beams. Requirements for the external beam as presently planned, include a separate internal and external magnet system for beam deflection, a separate 1,500 kilowatt power supply, and additional shielding and utility connections.

Conversion of the electron synchrotron from 340 million electron volts to 500 million electron volts will allow higher energy research than is possible at present and will give increased range of experience to graduate students in the laboratory program. The requirements for this development include improvement of the accelerator's magnetic field, sophistication of the F.M. system and increasing the power supply.

8. Project 59–e–7 Chemistry hot laboratory, Argonne National Laboratory, $4,415,000.—This project provides for the construction of a hot laboratory that will be connected to the present chemistry building at the Argonne National Laboratory. The levels of radioactivity encountered in nuclear chemistry research have increased substantially in recent years and even greater increases are essential to the continuation of an effective program in this area. The availability of research reactors with substantially greater flux and particle accelerators with higher energies insures that the increases in the levels of activity will continue.

The transplutonium element program illustrates the inadequacy of the present facilities and the trend toward higher level radiation experiments in the chemistry program. In the study of the transplutonium elements, the Chemistry Division has processed sizable amounts of irradiated plutonium. In the past the remote processing of the irradiated plutonium has been done in the Building 40 cave, where shielding and working space in several instances has not been adequate. The Chemistry Division is now engaged in a new program of irradiating plutonium fuel rods to produce larger quantities of the transplutonium elements. Previous experience indicates that the existing Building 40 cave will be completely inadequate in gamma ray shielding, containment of alpha activity and available working space when quantities of irradiated plutonium of this magnitude are processed. The substantial neutron emission arising from spontaneous fission of the curium and californium produced in the irradiated plutonium and from the alpha, neutron reactions will be an additional hazard that will make the present facilities inadequate.

In 1958 and 1959, when the first of the fuel rods now in the MTR are ready for processing, arrangements have been made to make use of the chemical engineering hot cave which is now under construction. This facility will not be available for regular use, however, because of the requirements of the reactor development program for the chemical processing of spent fuel elements.

This program is one of a number of equally important chemistry programs that will require a facility of the type proposed in this project in order to continue their investigations at higher radiation levels. The following programs will also require similar special shielded facilities:

1. Micro studies of intensely radioactive nuclides.
2. High flux studies.
3. Chemical and physical studies of radiation effects.
4. Chemical and radiochemical analytical studies.
5. High level alpha experiments.

9. *Project 59–e–11 High flux research reactor, Brookhaven National Laboratory, $9 million.*—This project provides for the construction of a high flux research reactor at Brookhaven. An appropriation of $1 million was authorized in fiscal year 1959 for design work and special procurement. The total authorization is being increased in fiscal year 1960 to $10 million to provide for construction of the reactor. This request of $9 million provides the balance of funding. The reactor will use fully enriched uranium-aluminum fuel elements, with heavy water as a moderator, coolant, and reflector. When operated at 20 megawatts of power, it will provide a total flux of 1.5 by 10^{15} neutrons per square centimeter per second in the reactor core and a thermal flux of 5 by 10^{14} in the reflector.

A higher flux reactor is needed at Brookhaven to satisfy two needs: (1) Experiments which could be done with a higher flux reactor in a matter of days now require weeks and months to complete. The demonstrated advantages of such a machine as the "fast chopper" in yielding significant data in regions of energy requiring a high flux of resonance neutrons, become almost wasted if such neutrons are not available in sufficient amount to permit such data to be acquired in reasonable amounts of time. (2) Many experiments do not give significant results without sufficiently high flux to yield detectable effects. Some of these are due to the ratio between flux and background effects; others such as the manufacture of certain radioisotopes of short half life require higher fluxes in the first instance.

In addition to the need for higher fluxes in general, this proposal recognizes the need for higher fluxes in an energy range above thermal. Thus, emphasis has been placed on a core design which will maximize such fluxes and the design of the experimental facilities has been such that maximum advantage is taken of the high resonance flux. It is felt that a most serious lack of basic data still exists in this neutron energy range and, therefore, future work should emphasize greater precision in neutron interaction measurements for the energies.

10. *Project 59-e-13 Van de Graff accelerator, Argonne National Laboratory, $2,500,000.*—The present ANL Van de Graaff which was built in 1948–49 has a maximum energy of 3.5 million electron volts and is now operated in excess of two full shifts. A third shift will probably be provided shortly. The Laboratory has developed a very capable staff in this area of work which provides insurance that the full potential of the 10 million electron volts machine will be exploited. In addition it is essential that the Laboratory's Van de Graaff closely associated to ANL primary mission, namely reactor development. Some of the investigations which would be particularly interesting at the higher energies (up to 10 to 12 million electron volts are—

1. The high energy machine could bridge the neutron gap between 10 to 14 million electron volts. The precision neutron cross-section program could, therefore, be extended through this region.

2. Basic scattering problems; very few measuresments of high precision exist in the energy range 6 to 11 million electron volts for the important problems.

3. Elastic scattering: Of particular interest, for example, is scattering by zero-spin nuclei for which unambiguous spin and parity assignments could be made to States not heretofore investigated.

11. *Project 59–e–15 Research reactor, Ames Laboratory, $3,765,000.*—This project provides for the construction of a research reactor and the construction and initial equipping of the related building at Ames Laboratory. The proposed reactor is a thermal heterogeneous reactor of the type of the Argonne CP–5 reactor, using highly enriched fuel, cooled and moderated with heavy water. The acquisition of a reactor by the Ames Laboratory will round out the basic research programs now in progress in chemistry, physics, metallurgy, and engineering, and will assist the Laboratory to produce pure metals and other materials for use throughout the atomic energy program. At the present time the pure metal program is expanding rapidly. Analytical control, however, is essential for the production of these materials. A reactor as a part of the Laboratory's facilities will permit the development of a program in activation analysis which in turn will improve the quality of the materials being produced. Other programs which require the use of a reactor are those requiring structural analysis by neutron diffraction and chemical and metallurgical programs requiring isotopic tracers of short half life.

There are large areas of engineering where fundamental research must be done in order to keep ahead of the applications of the results of such research in actual practice. A laboratory, like Ames Laboratory, which is not completely concerned with application and development, is the ideal place for such research. The reactor would also benefit the Nation's atomic energy program as a training facility. For the past 4 years, Iowa State College has had a nuclear engineering curriculum for graduate students leading to a master's degree. This would expand and become more effective if a reactor were available to the faculty and students.

12. *Project 57–d–1 High energy accelerator, $15,500,000.*—This project will provide a much needed accelerator in the United States at an energy and intensity not otherwise available. The proposed machine will provide a copious source of antiprotons and antineutrons and will thus open the whole field of "antimatter" reactions for precise experimentation. The bevatron at the E. O. Lawrence Radiation Laboratory has permitted the discovery of these particles but its energy range is too low for their production on a scale for precise experimentation. The intensity of the machine will be capable of producing a beam containing 10^{13} particles per minute which is greater by a factor of 15 or 20 than that expected to be produced by the alternating gradient synchrotron now under construction at the Brookhaven National Laboratory.

A high energy accelerator project was authorized in fiscal year 1957 (project 57–d–1) for $15 million. The justification for that project was made on the basis of an urgent short-range need for extending the energy range beyond that of presently available machines. The site and specifications for the machine were undetermined at the time of its authorization.

Subsequent to the authorization of that project, the Argonne National Laboratory was selected as the site for this machine and a study was conducted to determine what type of an accelerator could be built for $15 million. It was found that any accelerator built for this amount would be essentially a duplication of an existing machine or one already under construction in the United States. Accordingly, the desirability of constructing such a machine was reconsidered, especially in the light of the fact that the National Science Foundation's Advisory Panel on High Energy Accelerators had recently recommended that first priority be given to those machines that give promise of extending the important accelerator parameters to new ranges. As a consequence, it was decided to increase the authorization in fiscal year 1958 for this project to $27 million. The most recent total estimated cost is $29 million. The amount of $13,500,000 has been appropriated in prior fiscal years; the balance of $15,500,000 is requested in fiscal year 1960 in order to complete procurement of major long leadtime components, complete construction of all buildings, and to permit the orderly installation of all components of the accelerator.

13. *4019 Alternating gradient proton synchrotron, Brookhaven National Laboratory, New York, $5 million.*—This request provides for an additional $5 million to complete the funding of this project (increasing the total funding from $26 million to $31 million) in accordance with revised cost estimates for the Brookhaven alternating gradient synchrotron, now under construction.

The original proposal in 1953 was for an accelerator initially reaching 25 billion electron volts at an estimated cost of $20 million but capable of later extension to 35 billion electron volts at an additional cost approximating several million dollars. It was soon recognized, however, that a two-step design was not economically or technically attractive. Accordingly, the 1955 proposal was for an accelerator achieving approximately 33 billion electron volts in a single step and was estimated at $23,632,000 with a contingency of $2,368,000 to be allowed for a total estimated project cost of $26 million.

The 1957 proposal reflected increases in labor and materials which brought the estimated cost to $26,826,000 plus a contingency of $2,174,000 for a total estimated cost of $29 million.

Since 1957, it has become apparent that the full project salary and wage (with appropriate burden) and direct material costs must be carried to the end of fiscal year 1960 in order to complete assembly and installation by that date. Commitment experience and more precise estimating now indicate that the construction cost of providing the many components and structures in place must be increased. In addition, studies during the past year of the beam-handling equipment for preliminary operation and evaluation of the synchrotron made it apparent that the items previously budgeted were not adequate for setting up one complete external beam of particles. It was necessary, therefore, to increase the estimate for these items, which include shielding for the beam, four focusing units, four bending units (two sets at maximum energy), and the necessary power equipment with attendant motor-generator house and substations. All of the foregoing increases have added $1,864,000 to the 1957 estimate and bring the present estimated cost excluding contingency, to $28,690,000. A contingency of $2,310,000, representing approximately 30 percent of the uncompleted work as of April 30, 1959, brings the total accelerator cost to $31 million.

SECTION B

The projects comprising section B which have been previously authorized and for which funds have previously been appropriated but are now carried over into fiscal year 1960 are:

Project No.	Title	Total estimated cost	Funded through fiscal year 1959	Obligations to be incurred in fiscal year 1960	Funding required after fiscal year 1960 to complete project
59-e-4	Cyclotron, University of California Radiation Laboratory	$4,811,000	$711,000	$4,100,000	0
59-e-8	Expansion of stable isotopes production capacity, Oak Ridge National Laboratory	900,000	500,000	400,000	0
59-e-14	Cyclotron, Oak Ridge National Laboratory	3,000,000	1,000,000	2,000,000	0
57-d-4	Conversion of accelerator design building, University of California Radiation Laboratory	300,000	0	300,000	0
57-h-2	Physics building, Brookhaven National Laboratory	3,300,000	300,000	3,000,000	0
57-h-3	Engineering building, Brookhaven National Laboratory	1,879,000	535,000	1,344,000	0
56-c-1	Particle accelerator program	21,406,000	19,406,000	2,000,000	0
	Cambridge Electron Accelerator	10,200,000	8,200,000	2,000,000	0
	Princeton-Penn Accelerator	11,206,000	11,206,000	0	0
	Total	35,596,000	22,452,000	13,144,000	0

Mr. CANNON. Last year the committee inserted in the bill funds for a number of unbudgeted items. I wish you would give us for the record what you have accomplished in these projects for which this money was provided.

(The information to be supplied follows:)

Status of projects as of June 30, 1959, under the physical research program for which funds were provided in the 1959 appropriation for unbudgeted items

The 1959 Appropriation Act provided an increase of $26,179,000 against a list of projects for which estimates had not been included in the budget. The total estimated costs of these projects were $41,829,000. The status of each of the projects is as follows:

Project No.	Project title	Amount appropriated in 1959	Current estimate of cost	Status of project
57-h-1	Permanent research buildings, Oak Ridge	$5,780,000	$5,555,000	Construction 53 percent complete.
57-h-2	Physics building, Brookhaven Laboratory	2,140,000	3,300,000	Title I preliminary design completed. Title II detailed design 10 percent complete.
57-h-3	Engineering building, Brookhaven Laboratory	1,879,000	1,879,000	Construction 5 percent complete.
57-h-4	Engineering service building, University of California Radiation Laboratory.	1,080,000	1,188,000	Construction 3 percent complete.
57-d-4	Conversion of accelerator design building, University of California Radiation Laboratory.	300,000	300,000	Construction delayed pending completion of project 57-h-4.
59-e-1	Accelerator improvements, University of California Radiation Laboratory.		800,000	Of the $800,000 of improvements undertaken in fiscal year 1959, construction was 20 percent complete and on schedule.
59-e-3	2 accelerator improvements, Penn State University		0	Penn State University has purchased with its own funds a 5.5-Mev Van de Graaff generator. Following discussions between the AEC and the university, the Commission is supporting a research program with the use of this machine under its operating funds.
59-e-4	Cyclotron, University of California Radiation Laboratory		4,811,000	Design of the cyclotron building was 55 percent complete, and design and development of the machine by the Lawrence Radiation Laboratory was 14 percent complete. Construction started in early June and was 1 percent complete at month's end.
59-e-5	Central Research Laboratory addition, Oak Ridge		3,057,000	Construction was 11 percent complete at the end of June.
59-e-6	Chemistry building addition, University of California Radiation Laboratory.		2,000,000	Design was 33 percent complete at the end of June, with construction scheduled to start in November.
59-e-7	Chemistry hot laboratory, Argonne	15,000,000	4,415,000	Funds for the construction of this project are included in the 1960 appropriation request.
59-e-8	Expansion of stable isotopes production capacity, Oak Ridge		900,000	Construction was 7 percent complete at the end of June.
59-e-9	High energy physics building, Columbia University		500,000	Design was 95 percent complete at the end of June with construction bids to be received by July 13.
59-e-10	Particle accelerator program addition, Harvard-MIT accelerator		1,430,000	Construction was 15 percent complete at the end of June.
59-e-11	High flux research reactor, Brookhaven		1,000,000	Assembly of the critical experiment was completed and criticality was reached in June. Preparations for the selection of an architect-engineer were being made.
59-e-12	Research and engineering reactor, Argonne		0	Further review of this project by ANL indicated it would not be adequate to meet the Lab needs. A conceptual design of a special high flux reactor was under study.
59-e-13	Van de Graaff accelerator, Argonne		2,500,000	Funds for the construction of this project are included in the 1960 appropriation request.
59-e-14	Cyclotron, Oak Ridge		3,000,000	Title II work was started in June with preliminary design of specialized equipment under way.
59-e-15	Research reactor, Ames Laboratory		3,765,000	Funds for the construction of this project are included in the 1960 appropriation request.
	Total	26,179,000	40,400,000	

Biology and Medicine

Mr. Cannon. Under "Biology and medicine" you are requesting $3,882,000. We shall insert pages 329 through 330.

(The pages follow:)

Biology and Medicine Program—Construction Obligations

Program statement

Estimated obligations fiscal year 1960	$3, 382, 000
A—Obligations for new projects	(3, 382, 000)
B—Obligations for prior year projects	(0)
Estimated obligations fiscal year 1959	2, 600, 702
Actual obligations fiscal year 1958	1, 245, 068

Obligations for the biology and medical program for fiscal year 1960 are estimated at $3,382,000, all of which is for new projects justified in section A below which were authorized in the fiscal year 1960 Authorization Act.

SECTION A

The projects comprising section A are as follows:

Project No.	Title	Total estimated cost	Funded through fiscal year 1959	Estimated obligations, fiscal year 1960	Funding required after fiscal year 1960 to complete project
60–h–1	Installations for support of biomedical research projects in atomic energy	$3, 000, 000	0	$3, 000, 000	0
60(1)	General plant projects	382, 000	0	382, 000	0
	Total	3, 382, 000		3, 382, 000	

Explanation of projects in section A

1. *Project 60–h–1. Installations for support of biochemical research projects in atomic energy, $3 million.*—The project will provide installations required to strengthen and help expedite research activities in the fields of radioactive fallout problems and biological hazards of radiation. The recent hearings on fallout from nuclear weapons tests as conducted by the Joint Committee on Atomic Energy have emphasized the need for forging ahead as rapidly as possible with research projects related to radiation protection studies and to provide as promptly as possible the additional facilities needed for such studies. These would include, but not necessarily be limited to—

(1) Additional laboratory and animal holding facilities for expansion of long-term genetic and toxicity studies using mice and other small animals.

(2) Physiological laboratories to house additional experimental biological studies, particularly on radiation protection and recovery.

(3) Large animal installations for genetic and fission product metabolism studies of sheep, cattle, swine, and other animals.

(4) Low background level installations for measurement of body burdens of specific isotopes.

(5) Installations to study radiological and physiological aging.

2. *Project 60(1). General plant projects, $382,000.*—The purpose of this project is to provide for miscellaneous alterations, improvements, and minor additions to general plant and research installations of the biomedical research program necessary to improve efficiency of operation, correct safety and security hazards, and facilitate advances in research. The estimate, based on past experience as to requirements, will cover the necessary improvements at Commission-operated laboratories in the life sciences, as well as minor construction or alterations required by biology and medicine Commission-supported research at universities and other research institutions.

Training Education and Information

Mr. Cannon. Under "Training education and information" you are requesting $1,025,000. We shall insert pages 331 and 332.

(The pages follow:)

Training, Education, and Information Program—Construction Obligations

Program statement

Estimated obligations fiscal year 1960	$1,025,000
A—Obligations for new projects	(150,000)
B—Obligations for prior year projects	(875,000)
Estimated obligations fiscal year 1959	914,935
Actual obligations fiscal year 1958	2,710,965

Obligations for the training, education, and information program for fiscal year 1960 are estimated at $1,025,000, of which $150,000 is for the project justified in section A below which is authorized in the fiscal year 1960 authorization act. The balance of $875,000 is for projects listed under section B below which were authorized prior to fiscal year 1960 and for which funds have previously been appropriated but are now carried over into fiscal year 1960.

SECTION A

The project comprising section A is as follows:

Project No. 60–1; title, General plant projects:	
Total estimated cost	$150,000
Funded through fiscal year 1959	0
Estimated obligations, fiscal year 1960	150,000
Funding required after fiscal year 1960 to complete project	0

Explanation of projects in section A

Project 60–1 General plant projects, $150,000.—This project provides for minor additions to the training and research facilities of the Puerto Rico Nuclear Center operated for AEC by the University of Puerto Rico. The PRNC began limited operations, using university facilities, during fiscal year 1958. Construction of the initial AEC facilities is now underway and is scheduled for completion during fiscal year 1960. As the program evolves it is expected that requirements will arise for minor capital work not included in the basic PRNC construction project.

To provide for such minor facility additions, which are already recognized or which may be recognized during fiscal 1959 and fiscal year 1960, to obtain either safety in operations, efficiency, and effectiveness in research and training programs, or accomplishment of program objectives, it is proposed that this general plant project be established in fiscal year 1960 for Puerto Rico Nuclear Center in the amount of $150,000. Examples of the type of work to be performed under the project in fiscal year 1960 follows:

Construction of an elevated water tank and appurtenances to provide an adequate water supply for fire demands, and potable and process water for the reactor and laboratory during emergencies at the Puerto Rico Nuclear Center when the city water supply is not adequate. Water requirements are (1) storage of a 2-hour supply for fire protection, and (2) a 2-hour supply for reactor and laboratory shutdown.

The design of the PRNC research reactor at an operating level of 1 megawatt and using standard criteria does not include a holdup tank for the water in the reactor pool. The purpose of such a holdup, or decay, tank would be to hold up the cooling water passing from the pool through the heat exchangers and back to the pool for a sufficiently long period to allow the decay of induced activity of short half-life isotopes. However, the need for such holdup facility is dependent upon the final reactor design; also future reactor hazards evaluation based on additional studies of the uncertainties involved may indicate a need for this facility.

SECTION B

The project comprising section B which have been previously authorized and for which funds have previously been appropriated, but are now carried over into fiscal year 1960 are:

Project No.	Title	Total estimated cost	Funded through fiscal year 1959	Obligations to be incurred fiscal year 1960	Funding required after fiscal year 1960 to complete project
59-g-1	Additional plant for the regional nuclear training center, Puerto Rico	$500,000	$25,000	$475,000	0
59-g-2	International Atomic Energy Agency research reactors and laboratory equipment grant	1,000,000	600,000	400,000	0
	Total	1,500,000	625,000	875,000	0

Civilian Application of Isotopes and Nuclear Explosives Program

Mr. Cannon. Under civilian application of isotopes and nuclear explosive program you are asking $3,400,000. We shall insert pages 333 through 336.

(The pages follow:)

Civilian Applications of Isotopes and Nuclear Explosives Program—Construction Obligations

PROGRAM STATEMENT

Estimated obligations fiscal year 1960	$3,400,000
A—Obligations for new projects	($3,400,000)
B—Obligations for prior years projects	(0)
Estimated obligationss fiscal year 1959	0
Actual obligations fiscal year 1958	0

Obligations for the isotopes and plowshare programs for fiscal year 1960 are estimated at $3,400,000, of which $3,400,000 is for the projects justified in section A below which were authorized in the fiscal year 1960 Authorization Act.

SECTION A

The projects comprising section A are as follows:

Isotopes development program, fiscal year 1960

Project number	Title	Total estimated cost	Funded through 1959	Estimated obligations	Funding required after fiscal year 1960 to complete project
60-i-1	High-level Radiation Development Laboratory	$1,600,000	0	$1,600,000	0
60-i-2	Radioisotope Process Development Laboratory	1,500,000	0	1,500,000	0
60-j-1	Radioisotope production area expansion and modifications, ORNL, Tennessee	300,000	0	300,000	0
	Total	3,400,000	0	3,400,000	0

Explanation of projects in section A

1. *Project 60–i–1 High-Level Radiation Development Laboratory, $1,600,000.*—It is proposed to construct a permanent building which will serve as a laboratory for research in the utilization and development of radioactive sources providing very intense radiation over relatively large volumes. This building will have a gross area of about 12,000 square feet, of which more than half will

be in one high room containing laboratory facilities which will consist of two shielded cells and a canal. An experiment preparation cell will receive radiation source material in elemental form, to be tested and capsulated into containers for use in evaluation experiments. In the experiment irradiation cell, materials will be exposed for high-level irradiation studies and evaluation of various geometric arrangements of sources. The canal will be used for storing, transporting, and setting up experimental encapsulated sources.

As the U.S. nuclear economy expands, there is an increasing availability of by-product neutrons for isotope production, and, of course, an increased inventory of fission products is being accumulated. Many practical applications of these sources of radiation power are at the stage where proper evaluation can be made only if engineering information on source technology is obtained. This project is directed toward attainment of such information.

2. *Project 60–i–2 Radioisotope Process Development Laboratory, $1,500,000.*—This project provides for the construction of a laboratory at a site to be determined to be used for research and development studies on application of radioisotopes and fabrication of radiation sources.

The proposed building will be a reinforced concrete and structural steel framed two-story structure, 40 by 150 feet. The building will provide a gross floor area of approximately 12,000 square feet. The first floor will contain four hot cells, a cell-operating area, four offices, one laboratory, a change room, storage and utility areas, and the first level of a three-level chemical engineering area. The chemical engineering area will occupy a space approximately 38 by 28 feet and will consist of three levels of steel grating floors on steel supports. The second floor will provide space for four offices, three laboratories, storage and utility areas, and the third level of the chemical engineering level. The building is to be air conditioned except for the area occupied by the hot cells and the chemical engineering area.

Under Government policy, AEC normally does not engage in direct competition with private business in the development and routine production of radioisotope utilization devices. While some work on the utilization of radioisotopes is done by private laboratories, it is largely company confidential work, usually directed toward specific, limited objectives, and is not reported in the literature. The projects to be pursued in this laboratory will not be directed toward developing specific products or processes, but rather will provide information of type obtained from pioneering research to be used in stimulating applied research.

3. *Project 60-j-1 Radioisotope production area expansion and modifications, Oak Ridge National Laboratory, Tennessee, $300,000.*—This project provides for various alterations, and modifications to the ORNL radioisotope production area as follows:

Extension of building 3033: By the addition of two walls, a roof, and a concrete pad, additional space will be provided to meet the growing demand for production of radioactive gases.

Additions to radioisotope packing and shipping facility: To provide a safer facility (from a radiological standpoint) for the packaging and shipping of radioisotopes, it is proposed to add to the present facility; radiation shields, viewing window, manipulators, shielded conveyors, and remote taping and canning machines.

Dual purpose cell for building 3029: This cell only requires the addition of two shielding walls and roof. The cell is required to provide adequate space and handling facilities to reduce the radiation exposure level to personnel during final decontamination of tools and apparatus used in manipulator cells.

Modification of cells and laboratory in building 3026–C: An existing cell in building 3026–C will be converted to a manipulator cell and an existing laboratory will be refurnished. This will provide interim space and facilities for necessary radioisotope process development and utilization studies.

Promethium 147 manipulator cell, building 3028: This cell is to be located on the east side of building 3028 with the operating face inside the existing building. This cell is needed to accomplish final purification and concentration of promethium 147 produced in FPPP.

Manipulator cell, building 3031: This is a cell of simple construction design to provide remote operating facilities to carry out those elements of processing, considered low level, which are being presently done under "planned for" exposures. The reduced radiation tolerances now in effect make it imperative that all hot work be done by remote operation.

The growth of the radioisotope production and distribution program has caused existing facilities to become inadequate for efficient operations and radiological safety of operation personnel. To eliminate this condition, the above expansions and modifications are essential.

Mr. CANNON. How will you use those funds, Mr. Chairman?

HIGH LEVEL RADIATION DEVELOPMENT LABORATORY

Dr. AEBERSOLD. This is identified as two major facilities: one, a high level radiation development laboratory, which would be placed at our Brookhaven National Laboratory. It will be able to handle sources of fission products equivalent to 4 tons of radium in radiation output. There is no such facility available anywhere for the type of research and development we want to do here of using radiation power. We would actually have kilowatts of radiation energy at our disposal for studying its possible uses. This is one of the things looking forward to practical uses of large quantities of fission products.

LABORATORY FOR DEVELOPING NEW ISOTOPES

The other facility is a laboratory for developing new isotopes and new types of radiation sources. This would be placed at Oak Ridge and is very essential to many phases of isotope application, including the military uses in the SNAP program, the isotope batteries.

Third, is the $300,000 item for modifying and bringing up to date the isotope production area at Oak Ridge. The amount of isotopes handled there is about 10 times what it was in total output when the facility was built in 1950.

Mr. CANNON. I was going to ask about that. You say facilities were constructed in 1950?

Dr. AEBERSOLD. Yes, sir.

Mr. CANNON. What is being done with those facilities?

Dr. AEBERSOLD. They are 8 years out of date in some respects in meeting the needs of the program.

Mr. CANNON. Have they not been kept up with the progress of the times?

Dr. AEBERSOLD. I am afraid not. There is always competition for funds. They have always been very modest in asking for expansion and modification of these facilities.

Mr. CANNON. Is this work supplementary or replacement?

Dr. AEBERSOLD. This is adding to the present facilities, sir.

Mr. CANNON. You just told us they were old and out of date. I take for granted that to that extent they are inefficient. You say you are merely going to add these?

Dr. AEBERSOLD. I mean this; this $300,000 item is in the final processing area where you finally put the packages together. The routine production of carbon 14, production of iodine, production of phosphorous, and other major items—facilities for those are adequate and all right. Where you package the material the levels of radiation, amount of isotope per package has been going up by quite a factor in the last few years. Also the exposure level people can be exposed to has come down from three-tenths of a roentgen per week to one-tenth of a roentgen per week. We thus need to modernize and put in more shielding to allow these people to work in this

area. It has become necessary because both the level of activity has gone up and the permissible radiation exposure has come down. We need this to give the isotope production workers better protection.

Mr. CANNON. You need the entire amount?

Dr. AEBERSOLD. Yes, sir.

COMMUNITIES

Mr. CANNON. Under "Community program" you are asking $2,775,000. We shall insert pages 337 through 339.

(The pages referred to follow:)

COMMUNITY PROGRAM—CONSTRUCTION OBLIGATIONS

Program statement

Estimated obligations fiscal year 1960	$2,775,000
(*a*) Obligations for new projects	(2,775,000)
(*b*) Obligations for prior year projects	(0)
Estimated obligations fiscal year 1959	2,785,745
Actual obligations fiscal year 1958	5,206,757

Obligations for the "Community program" for fiscal year 1960 are estimated at $2,775,000 for the projects justified in section A below which were authorized in the fiscal year 1960 Authorization Act.

SECTION A

The projects comprising section A are as follows:

Project No.	Title	Total estimated cost	Funded through fiscal year 1959	Estimated obligations, fiscal year 1960	Funding required after fiscal year 1960 to complete project
60-k-1	High school additions, Los Alamos, N. Mex	$485,000	0	$485,000	0
60-k-2	Real estate development, Los Alamos, N. Mex	240,000	0	240,000	0
60-k-3	Housing alterations, Los Alamos, N. Mex	1,000,000	0	1,000,000	0
60(1)	General plant projects	1,050,000	0	1,050,000	0
	Total	2,775,000	0	2,775,000	0

Explanation of projects in section A

1. *60–k–1 High school additions, Los Alamos, N. Mex., $485,000.* This project will provide approximately 24,000 square feet of additional space required to accommodate the high school enrollment during 1960–62 school years. High school enrollment is now 680 and is expected to increase to 915 during the 1961–62 school year. School facilities are presently fully utilized and it is necessary to add classrooms, science laboratories, and music facilities. A girl's gym is also required in order to provide a 4-year physical education program for this expanded enrollment.

Construction of these facilities is scheduled to start in the second quarter of fiscal year 1960 and to be completed in the first quarter of fiscal year 1961.

2. *60–k–2 Real estate development, Los Alamos, N. Mex., $240,000.* This project provides for the development of 47 additional lots on Barranca Mesa, which lies immediately north and in proximity to the main Los Alamos community. The estimate covers the cost of providing the necessary utilities, roads, appurtenances and lot development.

Adequate housing has long been known to be a prime consideration in the attraction and retention at Los Alamos of the high caliber technical and scientific personnel required to conduct the programs at the Laboratory. This project which continues a program now underway will enable Los Alamos personnel

to build the size and type of housing they desire. Moreover, it will make it possible for Laboratory personnel to spend their full working careers at Los Alamos with assurance of being able, upon retirement, to remain residents of the community. Such permanence of residence will make it possible to utilize the services of retired employees on a consulting basis. The program has the further advantage of partially meeting the need for improved housing at Los Alamos on a basis which will permit the Government to recover development costs through revenues from the sale of lots and utilities.

Funds for the development of 72 lots were appropriated in fiscal year 1958. All of these lots have been sold and the excellent response to the initial offering indicates that additional lots will be required to meet the demand for private residential construction.

Construction under this project is scheduled to start in the first quarter of fiscal year 1960 and to be completed during the third quarter of fiscal year 1960.

3. *60–k–3 Housing alterations, Los Alamos, N. Mex., $1 million.* This project provides for the modification of existing housing units to meet the shelter space requirements of growing families and provide better quality housing for senior staff members and other key personnel of the Los Alamos Scientific Laboratory (LASL). The proposed work will consist of additional bedrooms, bathrooms, laundry space, storage area, and similar changes.

A program is currently underway at Los Alamos to modify existing units by adding extra bedrooms and bathrooms. In a sense this represents a new phase in the housing construction program at Los Alamos. Prior to fiscal year 1958, efforts to improve housing were directed toward the replacement of temporary wartime structures. While this replacement program accomplishes much, it has not provided the quality housing which a substantial number of laboratory personnel would occupy in a normal community nor has it fully met the needs of increased family size.

The new program is a recognition that something more must be done to provide additional space for growing families and more suitable housing for senior staff members of the Los Alamos Scientific Laboratory. The senior staff and other key scientific and management personnel of the laboratory are people with abilities in the highest demand throughout the country. The opportunities available to them are, therefore, numerous and attractive. If we are to hold present members of the laboratory staff and attract others of equal rank, a continued effort toward providing housing commensurate with the stature and requirements of these people must be made.

Construction of these facilities is scheduled to start in the second quarter of fiscal year 1960 and to be completed in the second quarter of fiscal year 1961.

4. *Project 60 (1) General plant projects, $1,050,000.* This project covers alterations, additions, replacements, and other general improvements of various types which are anticipated for schools, city roads and streets, sewage systems, municipal activities, water systems, electrical distribution systems, central steamplants, housing, business concessions, hospital and other community facilities. Normal operating requriements in past years indicate the need for numerous capital items each year in order to provide the most economical operation of facilities at the various communities. In addition to normal requirements, $175,000 will be required for exterior alteration of 152 concrete houses at Sandia Base.

COMMUNITY CONSTRUCTION

Mr. CANNON. You are extending your real estate holdings at Los Alamos. Why is additional land required?

General STARBIRD. At Los Alamos we have housing that will accommodate about 60 to 70 percent of the laboratory people there and something less than 50 percent of the nonlaboratory pepole who are employed up on the hill. This is for improvement of housing and the development of lots with the idea on the housing of keeping our higher grade people there so they will stay. When their families get bigger, there are modifications being made to certain houses to add rooms so they can take care of their families, older people when they come back, and the like.

Mr. CANNON. It is entirely for accommodations of personnel?
General STARBIRD. This is correct.
Mr. CANNON. Your personnel has increased.

ADMINISTRATION

Under "Administrative program" you are asking $700,000. We shall insert page 340.
(The page follows:)

ADMINISTRATIVE PROGRAM—CONSTRUCTION OBLIGATIONS

Program statement

Estimated obligations, fiscal year 1960	$700, 000
A. Obligations for new projects	(700, 000)
B. Obligations for prior year projects	(0)
Estimated obligations, fiscal year 1959	650, 438
Actual obligations, fiscal year 1958	4, 073, 301

Obligations for the administrative program for fiscal year 1960 are estimated at $700,000 for the project justified in section A below. This project was authorized in the fiscal year 1960 authorization act.

SECTION A

Project No.	Title	Total estimated cost	Funded through fiscal year 1959	Estimated obligations, fiscal year 1960	Funding required after fiscal year 1960 to complete project
60(1)	General plant projects	$700,000	0	$700,000	0

Explanation of projects in section A

1. *Project 60(1) General plant projects, $700,000.*—This project provides for alterations, additions, replacements, and other general improvements of various types at the Washington headquarters in Germantown, Md., and administrative facilities located in the field. Normal operating requirements necessitate a need for numerous capital items each year, many of which are of a recurring nature, for reasons of economy, safety, health protection, and efficient operations.

Mr. CANNON. Are there further questions? Mr. Jensen?
Mr. JENSEN. No further questions.
Mr. CANNON. Dr. Fenton?

SHIPPINGPORT REACTOR

Mr. FENTON. Yes. I have two things I would like to develop. One has to do with the Duquesne Light Co. Has Duquesne Light Co. given any indication that they are willing to construct the addition of electrical generating capacity at Shippingport? In this connection is it not true that Duquesne Light Co. is paying the Government more for the steam from the Shippingport reactor than Duquesne can produce it by a modern coal-burning steamplant?

Mr. MCCONE. With respect to the first part of your question, Duquesne Light Co. have the question of the additional generating facilities under consideration. The informal discussions with them give us reason to believe that they will reach a favorable decision.

If they do not act favorably, then we will not make the expenditures on the reactor itself because they would be without purpose unless Duquesne puts in the power generation.

We will not put in the power generation because that would result in a powerplant owned partly by Duquesne and partly by the Government and that would be an undesirable situation.

With respect to the price that they are paying for steam, I have heard it said that it is somewhat in excess of their cost of steam from modern conventional units. I have seen no verification of the figures; therefore, I would have to reserve judgment.

Mr. FENTON. Will the increase in reactor capacity at Shippingport permit a reduction in the price of steam to Duquesne in line with the cost from other sources?

Mr. MCCONE. I really cannot answer that.

Mr. FENTON. Now, Mr. Chairman——

Mr. MCCONE. Mr. Floberg has a remark on that.

Mr. FLOBERG. I understand there is a proposal in from the Duquesne Light Co. that is now being evaluated, so apparently they are taking the subject seriously enough to submit a proposal.

Mr. FENTON. You can elaborate on that for the record.

Mr. FLOBERG. We shall; yes, sir.

(The information requested is as follows:)

The Duquesne Light Co. on May 21, 1959, submitted its proposal to AEC for the installation of additional electric generating capacity at Shippingport. A special committee has been set up within AEC to review all aspects of the proposal and to formulate for Commission consideration an AEC negotiating position. Review of the proposal began June 15, 1959, and is progressing.

AIR FORCE NUCLEAR TEST FACILITY

Mr. FENTON. I understand that the Air Force has partially constructed a nuclear engineering test facility at the Wright Air Development Center at Dayton, Ohio. This was planned in connection with the crash program for nuclear aircraft propulsion system. It now appears that completion of this project is not essential at this time. The Air Force contends that this new project is necessary so as to permit testing of nuclear radiation effects on subsystems of any flight vehicle under an environmental condition.

We have been advised that two AEC experts advise that environmental conditions of temperature and humidity have an insignificant effect on nuclear radiation effects. These AEC experts indicated to our investigators that they were unwilling to be identified with any criticism of the Air Force.

I think we should have the opinion of AEC experts as to the need for these test facilities the Air Force wants to construct. In that connection I would like to ask this question.

With the present radiation test facilities now in existence or under construction by AEC or others, including the Air Force facilities at Forth Worth, Tex., and Marietta, Ga., is there any valid necessity for additional radiation test facilities such as that proposed at the Wright Air Development Center at Dayton?

Would the use of this proposed test facility duplicate work to be done at AEC or other existing test facilities?

General KEIRN. May I answer that question? The facility will not duplicate other existing facilities. It will add to the capability of the Nation's ability in nuclear testing area. The facility is a specialized facility to determine and test radiation effects on materials, complete components, that will become a part of any airborne vehicle

that has either a nuclear power source in it or is subjected to high nuclear radiations from some other reason.

Communications equipment sometimes breaks down under high radiation. There is no way to test equipment in existing reactors. This reactor will have large volumes in which major components and major equippages that go into an airplane can be put under environmental conditions which will not only only simulate altitude and temperature, but also the radiation that may come from an airburst of a bomb or from a powerplant that is installed in the airplane.

This facility is not duplicated in any other facility we have. The facility at Marietta, Ga., can perform some of the tests, but they cannot provide the environmental conditions unless you do it on a piecemeal basis, which is an expensive way of accomplishing it.

Mr. FENTON. You say that the facility at Marietta cannot do all of the work?

General KEIRN. That is correct.

Mr. FENTON. It is absolutely necessary to have it under environmental conditions?

General KEIRN. The experience in the Air Force has been that this is the case. We have provided environmental conditions, excluding nuclear conditions, for all of our subsystems that go into airplanes.

This is because on the test stand, unless they are under the environments in which they are going to be used in the airplane, we may not be able to evaluate the capability of the equipment to perform properly in its environment.

Mr. FENTON. You are cooperating with them?

General KEIRN. Yes, indeed.

Mr. FENTON. We have a difference of opinion then, of course, according to our report by some of your own experts.

How do you account for that?

General KEIRN. I would have to know who the experts were who had given the other opinion, Dr. Fenton. There are many opinions about this aircraft reactor program.

Mr. MCCONE. Mr. Chairman, since Dr. Fenton has indicated in his statement that apparently there was some expression from AEC sources of a feeling that this test reactor was unnecessary and therefore they wished to disassociate themselves for any responsibility, I would like, and the general manager would like to make an independent check and to submit a statement for the record in this particular matter, even though this is financed entirely by the Air Force and is not a matter of our budget.

Mr. CANNON. He may extend his remarks in the record, unless Dr. Fenton would rather go into it now, Doctor.

Mr. FENTON. As far as I am concerned, your opinion would hold with me. I just state what the report says.

It is your opinion, then, sir, this is necessary?

General KEIRN. It is my opinion it is, sir.

(This information is being furnished separately to the committee.)

Mr. FENTON. If you will make a separate investigation report we will appreciate that.

General KEIRN. Yes, sir.

Mr. CANNON. Has the gentleman concluded?

Mr. FENTON. Yes, sir.

Mr. CANNON. We shall stand adjourned.

INDEX

A

Page

Aircraft, nuclear 94, 95, 184, 369
Air Force nuclear test facility 385
Aluminum, purchases of 148, 152
Atomic weapons, designing and making 19

B

Biology and medicine:
- Accidents 48
- Agricultural uses for radiation 52
- Biomedical aspects of atomic energy 45
- Budget statement on 78
- Cancer research 112
- Cure of cancer 58
- Fallout problem 23, 24
- Food sterilization 33
- Genetic effects 48, 78
- Instruments to detect radiation 52
- Operating expenses 268
- Personnel 285
- Plant acquisition and construction 377
- Protective treatment prior to exposure 50
- Public Health Service, cooperation and division of responsibility with 24, 112, 283, 285
- Radiation effects 45, 48, 78, 282
- Research contracts 284
- Treatment for radiation 51

Budget estimates, 1960 ..... 70, 109
Budget statement 69

C

Cancer, cure of 58
Civilian application of isotopes and nuclear explosives:
- Agricultural experiment stations, cooperation of 313
- Budget statement on 79
- High Level Radiation Development Laboratory 381
- Operating expenses 305
- Plant acquisition and construction 379
- Plowshare program 24, 314
- Private industry, cooperation of 311, 312
- Program expansion, need for 309

Coal, future outlook for 34, 265
Communities:
- Budget statement on 80
- Disposals 94, 98
- Operating expenses 322
- Plant acquisition and construction 382

D

Designing and building of nuclear reactors. (See Reactor development, this index.)
Domestic exhibit program 156

E

	Page
Elementary physics and chemistry underlying the atomic energy program	14
Chemistry	14
Fusion energy	17
Making uranium 233	16
Matter, new forms of	18
The nucleus	15
England:	
Barter agreement with	114
Breeder plant	245
Development and progress in	3, 5, 81, 89
Gas-cooled reactor	4
Exchange of information through IAEA	155

F

Fallout problem	23, 24
Fellowships and grants to schools	92, 107, 304
Foreign atomic endeavor	81
Fusion energy, production of	17

H

High energy accelerators	44

I

Indemnity legislation	243, 267
Industry cooperation	74, 75, 86, 98, 188, 192, 247, 267, 311, 312
International Atomic Energy Agency:	
Exchange of information through	155
Isotopes:	
Agricultural uses of	54, 57
Basic service, uses in	57
Cancer, cure of	58
Civilian application of	305
Coal and grain, use in connection with	321
Development of	113
High intensities of radiation, uses of	57
Industrial materials, studies with	56
Laboratory for developing new	381
Medical uses	53, 110
Production and uses of	53, 110
Tracers	55
Units	43
Italy, atomic powerplant in	113

M

Matter, new forms of	18

N

Naval reactor development program	172
Aircraft, nuclear	184
Aircraft carriers, nuclear	191
Contractors, relationships with	182
Destroyers, nuclear	178, 190
Elimination of some research projects, desirability of	183
Industry cooperation	188, 192
Natural circulation reactor program	173
Nuclear cores, development of	190
Nuclear electric power program, importance of	181
Russian progress	185
Submarines, nuclear:	
Advantages of	191, 193
Crews, selection and training of	176
Need for additional	187
Russia, capacity to construct	186
Status of program for	175
Value of nuclear reactor program	180

Page

Nuclear electric power program, importance of 181
Nuclear power, cost of 91
Nuclear powerplants, cost of 116

O

Operating expenses 119
General statement on 123
Supplemental estimate, 1960 121
Unobligated and unexpended balances 129, 132
Orientation presentation 8
Other costs 334

P

Personnel, number of 110
Physical research:
Budget statement on 78
Chemical and metallurgical problems 264
Controlled fusion studies, progress in 262
Estimates, 1960, increase in 261
Linear electron accelerator 78
Off-site contract renewals, 1959 264
Operating expenses 249
Plant acquisition and construction 369
Thermocoupler principle of generating power 265
Unbudgeted construction projects, 1959, status of 376
Plant acquisition and construction 347
General statement on 350
Unobligated balances 352
Plutonium production 68
Program direction and administration:
Budget statement on 80
Operating expenses 322
Plant acquisition and construction 384
Public Health Service, cooperation and division of responsibility with 24, 283, 285
Public versus private power, discussion of 6

R

Radiation:
Agricultural uses for 52
Effects of 45, 48, 78, 82, 282
Fallout problems 23, 24
Genetic effects 48
Treatment 51
Raw materials:
Aluminum, purchases of 148, 152
Bonus payments 140
Budget statement on 70
Concentrate procurement policy 142, 147
Foreign exploration program 153
Operating expenses 133
Plant acquisition and construction 353
Purchase price of ores 81, 117, 153
Resource evaluation program 143, 147
Retaining reserves in the ground 141
Stockpiling, Commission policy on 145, 151
Thorium, stockpiling of 154
Uranium. (See this subject, this index.)
Reactor development:
Appropriation, 1959 and current estimates of cost, comparison of 229
Boiling water reactors 228
Budget statement on 72
Civilian power reactors 83
(*See also* "Shippingport reactor," this index.)
Control materials 29
Design and engineering studies 234
Designing and building of nuclear reactors 26

Reactor development—Continued Page

Detroit-Edison fast breeder plant 233
English breeder plant 245
Euratom, program for 238
Experiment fabrication 231
Experimental breeder reactor No. 2 234
Fast breeder reactors 246
Fission chain reaction 26
Fission products 32
Fluid fuel reactors 230
Fuel cycle development 76, 240
Fuel elements, problem of 37
Gas cooled power reactor 368
Heat, control of 28, 33
Improved cores 93
Industry and Government, contributions toward construction 87
Industry cooperation 74, 75, 86, 98, 188, 192, 247
International cooperation 75
Isotope units 43
Merchant ships, nuclear powered 76
Military reactors 76
Natural uranium heavy water reactors 236, 241
Naval program. (See this subject, this index.)
Nuclear superheat reactor 235
Operating expenses 195
Organic moderator reactor 232
Plant acquisition and construction 361
Plants under construction 244
Power production in past year 228
Power reactor demonstration program 368
Radioactive decay 29
Reactor concepts 38, 41, 99
Reactor features and uses 31
Reactor operation 27
Reactors systems research and development programs 239
Sales of reactors 84
Shield materials 30
Small nuclear superheat reactor 75
Sodium graphite reactor 38
Superheat reactor 237
Systems, description of 38, 41, 99
Value of program 180
Water cooled reactor 244
Revenues applied 335
Russia: Development in 8, 81, 115, 185

S

Security investigations 332
Selected resources 338
Shippingport reactor:
Duquesne Light Co., addition to generating facilities 384
Importance of nuclear electric power program 181
Improved cores 93, 227
Increased power at 227
Modification of reactor 73, 227
Operation and utilization of 83, 173
Reactor training school 299, 304
Special nuclear materials:
Budget statement on 71
Chemical separation process 68
Equipment 160
Estimates and actual costs 161
Hanford, new production reactor at 71
Operating expenses 157
Plant acquisition and construction 66, 347, 354
Plutonium production 68, 71
Power costs 158
Production plants for 66, 347, 354
Process development 161

V

T

Page

Testing:
Ban on 115
Eniwetok, maintenance of 166
Fallout problem 23, 24
Nuclear testing 166
Test sites, maintenance of 72, 166, 167
Underground testing 22
Weapons testing 21, 72
Training, education, and information:
Budget statement on 79
Cost distribution by categories and activities 298
Fellowships and grants to schools 92, 107, 304
International exhibits 302
Museums and special exhibits, fees for 301
Operating expenses 286
Plant acquisition and construction 378
Shippenport reactor training school 299, 304
Student interests in science, development of 109

U

Uranium:
Aspects of obtaining 61
Availability of 140
Content of ores 61
Developing new sources 62
Enriched uranium, production of 67
Making uranium 233 16
Oxide requirements 97
Process development 63
Purification process 66
Reserves 62, 146
Supply and price 81, 117, 153
Volume of production 64
World ore reserves 62, 150

W

Weapons, atomic:
Budget statement on 71
Defensive weapons, emphasis on 168
Designing and making 19
Eniwetok, maintenance of 166
Estimates and actual costs 168
Fallout problems from tests 23
Nuclear testing 21
Operating expenses 162
Plant acquisition and construction 358
Progress in building of 20
Requirements, determination of 170
Security of information 169
Stockpile:
Possible limit to 162
Quality of 165
Testing of weapons 21
Test sites, maintenance of 166, 167
Thermonuclear weapons 19
Underground testing 22
Use and deployment of 25

Y

Yankee Atomic Electric Co 89, 95

Z

Zirconium, supply of 36

○